DOCUMENT RESUME

ED 257 671 SE 045 767

AUTHOR	Peterson, Rita W.; Stenhouse, Lawrence
TITLE	Reviews of Studies of the Status of Pre-College Science, Mathematics, and Social Studies Education in the United States, 1955-1975. Sponsored by the National Science Foundation.
INSTITUTION	National Academy of Education, Washington, D.C.
SPONS AGENCY	Ford Foundation, New York, N.Y.
PUB DATE	81
NOTE	149p.
PUB TYPE	Viewpoints (120) -- Information Analyses (070)
JOURNAL CIT	Proceedings of the National Academy of Education; v7 1980
EDRS PRICE	MF01/PC06 Plus Postage.
DESCRIPTORS	Book Reviews; Case Studies; *Educational Change; Educational Research; Elementary Secondary Education; History; *Instruction; Literature Reviews; Mathematics Education; *Science Curriculum; Science Education; *Science Education History; Science Projects; *Social Studies; Surveys; *Teaching Methods
IDENTIFIERS	National Science Foundation; *Science Education Research

ABSTRACT

Two lengthy reviews are presented of a series of seven studies, sponsored by the National Science Foundation (NSF), on the subject of science education from 1950 to 1975. In "Science Education in the United States during the Third Quarter of the Twentieth Century", Rita Peterson provides an historical view of major events that occurred during the period (based largely on the literature review that formed the first NSF study). She next gives a cross-country view of the practices and opinions of school personnel (based primarily on the national survey that was the second NSF study). Lastly, she portrays a close-up view of what happened on a day-to-day basis in the classrooms of 11 school districts, as reported in the case studies comprising the third NSF study. In "Social Science Education in the United States 1955-1975: A British Perspective," Lawrence Stenhouse reviews the projects while focusing on social science education. The studies are analyzed from the point of view of the context in which they were commissioned and comments on "the picture we get", needs, errors, suggestions, and the issue of controversiality (itself a controversial issue). A brief 6-page concluding comment by Jerrold Zacharias on commitment and funding (titled "The Unscientific American--Some Random Thoughts") completes the volume. (MNS)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED257671

SE 045 161

The National Academy of Education

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

Reviews by

Rita W. Peterson
Lawrence Stenhouse

Comment by

Jerrold R. Zacharias

of

Studies of the Status of Pre-College Science, Mathematics, and Social Studies Education in the United States, 1955–1975, sponsored by the National Science Foundation

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

B. Bennett

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Proceedings of the National Academy of Education
Vol. 7, 1980
Copyright © by the National Academy of Education, 1981
All rights reserved.

BOOK REVIEWS*

---

*Edited by John B. Carroll. Preparation of these reviews has been sponsored by the National Academy of Education under a grant from The Ford Foundation for support of activities of the Academy concerning public understanding of research on education. The opinions expressed are those of the authors and do not necessarily represent the position of either the National Academy of Education or the Ford Foundation.

The Status of Pre-College Science, Mathematics, and Social Studies Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, (SE-78-71) by Stanley L. Helgeson, Robert E. Stake, Iris R. Weiss, et al. Washington, D. C.: Superintendent of Documents, U. S. Government Printing Office, (Stock No. 038-000-00383-6), 1978. 140 pp. $3.50.

Report of the 1977 National Survey of Science, Mathematics and Social Studies Education (SE-78-72), by Iris R. Weiss. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office (Stock No. 038-000-00364-0), 1978. 166 pp. + extensive miscellaneous appendices. $6.50.

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Vol. I: Science Education (SE 78-73 Vol. I), by Stanley L. Helgeson, Patricia E. Blosser, and Robert W. Howe. Washington, D.C.: Superintendent of Documents, U. S. Government Printing Office (Stock No. 038-000-00362-3), 1978. $4.25.

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975. Vol. II: Mathematics Education (SE 78-73 Vol. II), by Marilyn N. Suydam and Alan Osborne. Washington, D.C.: Superintendent of Documents. U.S. Government Printing Office (Stock No. 038-000-00371-2), 1977. $4.50.

The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975, Vol. III: Social Science Education (SE 78-73 Vol. III), by Karen B. Wiley with Jeanne Rice. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office (Stock No. 038-000-00363-1), 1978. 360 + 99 pp. $6.25

Case Studies in Science Education, Vol. I: The Case Reports (SE 78-74 Vol. I), by Robert E. Stake, Jack Easley, et al. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office (Stock No. 038-

000-00377-1), 1978. $7.25.

Case Studies in Science Education, Vol. II: Design, Overview, and General Findings (SE 78-74 Vol. II), by Robert E. Stake, Jack Easley, et al. Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office (Stock No. 038-000-00376-3), 1978. $6.50.

SCIENCE EDUCATION IN THE UNITED STATES DURING THE THIRD QUARTER OF THE TWENTIETH CENTURY

A review by
Rita W. Peterson*
California State University

---

*On leave as Director of Research in Science Education at the National Science Foundation in Washington, D.C. At California State University at Hayward, she is a professor of science education, teacher education, and biology. She received her M. A. (1967) and Ph.D. (1969) from the University of California, Berkeley. Her educational research centers on students' curiosity behavior, problem-solving ability and cognitive development. She is also a botanical illustrator and has published several books on California flora.

The author gratefully acknowledges support from California State University, Hayward, for preparation of this review, and wishes to thank Eugene Whitehorn for his illustration especially prepared for this paper.

This essay considers the question: How were the natural sciences and to some extent mathematics taught and learned in American elementary and secondary school classrooms between 1950 and 1975? This was a period which by coincidence ended on the eve before our nation's 200th birthday. For historical reasons that will become apparent, it was a period that deserves special attention.

Asking this question was prompted by interest on the part of the National Academy of Education in a series of reports sponsored and published by the National Science Foundation. They are referred to as the Status Studies and are described in detail in a moment. The task here is to review the NSF reports and reviews of them written by representatives of several professional societies. By choice, I have added a third dimension to the task, consideration of the historical context which surrounded the period of interest.

To provide some sense of the past, at least insofar as might be inferred from old textbooks, two excerpts from textbooks are especially pertinent; one is from science and the other from math, from a period shortly after our nation's 50th birthday.

In 1827 the Common School Manual gave teachers assistance in the form of a catechism to follow as they taught young scholars to un-

derstand the world around them:

> "A specimen is then taken up, say the Scarlet Pimpernel /a common weed or wild-flower/.
>
> Teacher How many stamens do you find in this flower?
> Pupil Five.
> Teacher It is therefore of what class?
> Pupil Of the fifth class, called Pentandria; and of the first order because it has only one pistil ...." (1)

Not much attention seems to have been given to curiosity, inquiry or critical thinking in these examples. Of course, mathematics was an equally serious business during this period as Welch's Improved American Arithmetic illustrates. Selling over 26,000 copies in its first edition in 1834, it was written for "use in schools and academies by experienced teachers." This popular little book took young scholars - in 220 pages - from their first counting lesson, through simple and compound addition, subtraction, multiplication and division, decimal and vulgar fractions, measurement of planes and solids, to such practical skills as bookkeeping in both American and English currency, and water levelling "to find whether water can be made to run from one place to another...." Math, then

as now, was designed to prepare students for adult life:

> "A man had a hundred dollars with which he bought 100 animals, consisting of oxen, sheep, and geese; for oxen he gave $10 a piece, for sheep $1, and for geese 1 shilling: How many of each did he buy?
>
> Ans. 54 geese = 9 dolls., 5 oxen = 50 dolls, and 41 sheep = 41 dolls. Proof: $100." (2)

Naturally science and mathematics education have changed during the intervening 150 years. Much more is known about how children and adults learn, and the amount considered to be appropriate to be learned in science and math has grown considerably.

Yet when Robert Stake and Jack Easley, Jr. recently published a report of observations from American schools during 1976, they found scenes like the following one quite common:

> "Eight fourth-graders were circled around the teacher for their social studies lesson. Miss Williams asked, 'Why is New York City a world city? At the top of page 142, why is New York City a world city?' (No answer)....Terry reads, 'New York is one of the great world cities,' and looks up ques-

tioningly. 'No, look on into the paragraph. The headquarters of the United Nations is there and trade with all the countries.'" (3)

And in a science lesson from the same report:

"Seeing nothing but inky black in the beaker they asked, 'What's supposed to happen?' The girl at the next table said, 'It's supposed to go up and down,' so they all wrote 'It went up and down,' in their lab reports." (4)

Unless one were aware of the major changes that have taken place during the past 25 years in science and math education, it would be easy to conclude that things have not changed much in American schools since the early 1800's. But between 1950 and 1975 the federal government invested over $650 million to improve the quality of instruction in science, mathematics and social studies in this country; more than 500 different projects were funded during this period. This unprecedented expenditure for education was justified as being in the interest of national security: Russia was surpassing us in key scientific advances. (5)

What was the impact of this heroic effort to improve science, mathematics and social studies instruction in American schools? That ques-

tion faced F. James Rutherford in 1976 as Assistant Director of the National Science Foundation:

> "After 20 years of trying to improve instruction in mathematics and in the natural and social sciences, what is the situation today? This question, particularly as it applies to elementary and secondary education, is of interest to the Foundation, to the National Science Board, to Congress, to all the thousands of teachers and scientists who participated in the reform effort in one way or another, and to education policy makers. It is a question that deserves an answer." (6).

To answer this question, the NSF consulted with leaders in these fields, and in the summer of 1976 commissioned three very different kinds of studies to assess the status of science, math and social studies education across the United States.

What follows in this essay is a brief examination of some important findings from these three studies that pertain to science - and to some extent mathematics, and a critical analysis of the interpretation given to these findings. And to those who might prematurely jump to the conclusion that the Great Reform in science education failed, that instruction had not changed

much from the catechetical examples of the early 1800's, a parting commentary is offered. But that's getting ahead of the story.

To provide a feeling for the events that occurred in science and math education during the third quarter of the twentieth century, and the significance of those events in American history, the three NSF reports are discussed in their larger social context and technical language has been sacrificed for the sake of clarity in describing events which affected the lives of all Americans.

The first section of this essay portrays an historical view of events between 1950 and 1975 as thousands of teachers, scientists and others were caught up in the major educational movement that changed what and how science and math were taught in American classrooms. This historical view is based largely on the first of the three NSF studies, an analysis of pertinent literature that was written between 1955 and 1975, that period of greatest NSF support. (7)

The second section of the paper presents readers with a cross-country view of the practices and opinions of school people during the school year that coincided with our nation's 200th birthday. This cross-country view is based primarily on the second NSF study, a national survey involving the perceptions of about

8500 people who worked in schools. (8)

The third section brings readers in for a close-up view of what actually happened on a day-to-day basis in the classrooms of eleven distinctly different school districts across the United States during 1976-1977. A two-volume collection and analysis of these eleven case studies furnished the primary material for this close-up view and represents the last of the three NSF studies. (9)

The final section of this essay presents a single straightforward conclusion drawn from the three NSF studies and the additional sources which fill in the background. It is followed by a critical analysis of an alternative conclusion derived by others who have interpreted the NSF studies. Readers are left with a question to consider. (10)

Section 1
AN HISTORICAL VIEW

The historical period surrounding the Great Reform in science and math education which began in the 1950's was filled with unprecedented technological and social changes: the first satellite in the world's history was launched; the first human stepped onto the surface of the moon; and Americans voted to launch a war on poverty and discrimination so that all citizens of the United States might have equal educational and economic opportunities. There were many other "firsts" during the third quarter of the twentieth century which shaped things to come.

Before taking a closer look at the events which occurred and affected science and math education between 1950 and 1975, briefly consider the task undertaken by Stanley Helgeson, Patricia Blosser and Robert Howe as they reviewed the immense literature of that period. It consisted of 140,000 citations from professional and technical journals and 125,000 non-journal publications (such as state education guidelines, program descriptions and so forth) that made some reference to science and mathematics education. From these 8,000 abstracts were considered especially relevant to science and math. Over 3,000 dissertations were included as were the files at the National Science Foundation and

the library at the National Institute of Education. By the time duplications were eliminated, the search was narrowed to 6,000 documents. From these approximately 10% were selected as representative, generalizable, summarizations of information and of major significance or historical importance. What did the literature of this period reflect?

The Call to Arms

The event which marked the beginning of the Great Reform in science and math education occurred about the time that James B. Conant convened a conference in 1953 to study the nationwide problems facing science teaching in the secondary schools. The Call to Arms was unmistakably sounded when Fletcher Watson and others, in a pre-Sputnik statement, formalized the concern of the time and gave a sense of mission to the reformation movement:

> "We need science teachers who have an awareness of scientific problems, who grasp every opportunity to encourage the inquisitive pupil toward further study and investigation, who know how to direct laboratory work and student projects, and who have a desire to make science classes a stimulating part of every high school curriculum ....When we consider how inevitably science affects our national economy and national

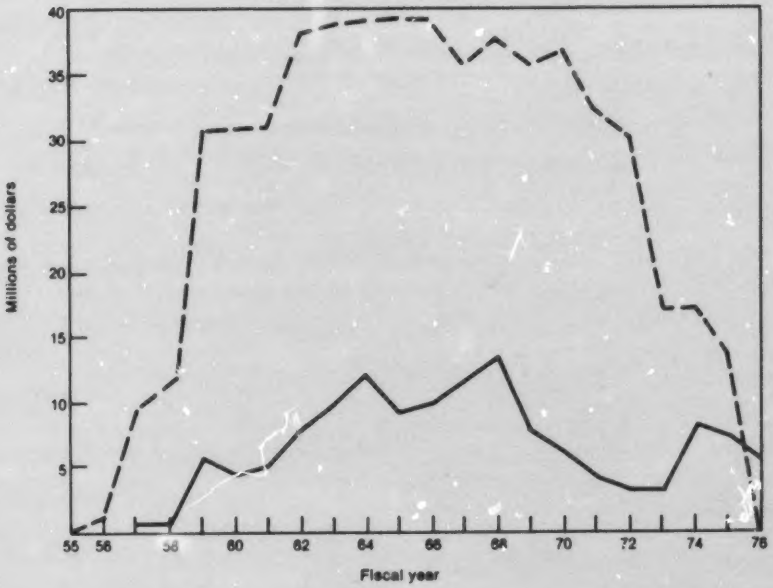
defense, mediocrity in science teaching is not only unsupportable, but perilous." (11)

The following year, 1954, the National Science Foundation funded the first summer institute for high school science teachers, an action which ushered in two decades of unprecedented federal support for educational reform. The momentum of the movement is probably no more vividly represented than in a diagram by Wayne Welch which shows the National Science Foundation's support of precollege curriculum improvement and teacher training between 1955 and 1976. (12)

The abrupt rise in funding stimulated as a response to Sputnik which flew in 1957 and to the comparably abrupt termination of funding around 1973 is a major topic of this review.

The Movement Gains Momentum

The early years of the science education movement set the model for how science and math instruction were to be improved in American schools during the next twenty years. The science teacher was seen as the crucial link in directing the nation's talented youth toward careers in science; thus, the greatest expenditures of NSF funds were allocated for teacher training to upgrade teachers' subject-matter knowledge, increase their repertoire of teaching skills and to transmit somehow a sense of the



Note. Solid line—amount in dollars obligated by NSF for precollege course content improvement; broken line—amount obligated for precollege teacher training.

Figure 1. NSF precollege curriculum development and teacher training support: 1955-1975.

(From W. Welch, Review of Research in Education 7:286 (1979).

excitement that scientists felt and hoped to pass on to American youth.

The $10,000 that was used to support the first summer institute in 1954, as Welch points out, increased rapidly to $30 million in just six years, and the number of summer institutes rose from 1 to 320, involving over 16,000 teachers annually. Over the twenty years, more than 50% of secondary school science teachers in the United States are estimated to have attended some NSF-funded training activity. (13)

But teacher training was only one of the three areas supported by NSF during the Great Reform. Instructional materials and equipment were also in need of improvement. The literature of the time contained many articles which identified the need for substantial development of instructional materials. Not only were curricular materials to be updated in terms of accuracy, but fewer ideas were to be presented to allow for in-depth study. More emphasis was to be placed on inquiry, a learning-by-doing approach which encouraged students to ask questions, and to think critically as they solved problems. Science was presented as a "way of knowing." (14)

The new science programs which were developed during the fifties, sixties and seventies were unique in several ways. First, the

programs were usually developed by teams of experts from several disciplines rather than by a single author or two as had been customary in previously published commercial textbooks. Scientists usually headed the teams and contributed new basic knowledge in science; often educational psychologists provided a basis for organizing instruction to take advantage of the newest research on how children and young adults learn and develop; and classroom teachers added practical knowledge about students' capabilities and existing school practices, based on their first-hand experience.

As author-teams developed materials, they field-tested them in classrooms throughout the United States. There was an unprecedented effort to custom-make the instructional material to fit the learner. University campuses generally served as headquarters for the major curriculum projects while nearby public schools served as the laboratories.

Variety was a hallmark of the new science programs. Many came in cabinets, kits, boxes, shelves and bags, all containing materials that were inviting to watch, touch or explore. Guppies, crickets and chameleons, seeds in countless variety to plant in interesting containers, and an equally irresistible assortment of objects from the world of physical science excited elementary pupils, while older students explored

natural phenomena with more advanced materials. Colorful booklets, soft-backed folders and cards often contained the "lesson" or instructions for students. There was an unmistakable air of excitement about these activity-centered or "hands-on" science programs which made the science textbooks of the early fifties pale by comparison, and a far cry from the catechetical kind of science seen in 1830!

The new science programs came to be known by the acronyms of their longer project titles. The Physical Science Study Committee, for example, became the PSSC program. It was followed by CBA, BSCS, CHEMS, HHP, ISCS, SAPA, ESSP, ESS, COPES, USMUS, and many more. (15)

Familiarity and verbal fluency with these acronyms were essential for anyone who was serious about teaching science or math, or concerned with training teachers in these fields. Jokes about the alphabet-soup science programs were numerous but they did not hide the sense of exhilaration and pride that was contagious among those who participated in the development and implementation of the new programs.

Teacher training and curriculum development were two of the targets identified in the Great Reform; change in teacher preparation and credentialing was a third target and area of pervasive change. Beginning in 1959, four confer-

ences were held in different geographic regions of the United States and involved representatives from the National Association of State Directors of Teacher Education and Certification, from the American Association for the Advancement of Science, and from subject matter areas in science, math and teacher education. The purpose of these conferences was to develop a set of guidelines that might be used by state directors of education and certification. The guidelines called for a general strengthening of subject matter preparation for all students who were training to become teachers, but the target group was future teachers of science, math and social studies. The new guidelines in 1961 were accepted, due in part to the mood of the times; Sputnik was still a rallying point. (16)

A Mission Accomplished

The most dramatic and visible outcomes of the Great Reform were found in teacher training workshops where teachers engaged in a new burst of scientific inquiry, and in classrooms where teachers and students together explored materials, pursued questions and learned how new knowledge in science and math is created. A film called "Don't Tell Me, Let Me Find Out!" captured the enthusiasm for learning that characterized many classrooms across the country. Regretably a review of the literature cannot capture that sense of energy. (17)

What did the literature during the third quarter of the twentieth century say about the outcomes of the reformation in science and math education? It is important for the next few movements to consider separately the two decades of NSF support as a movement which gained unparalleled growth during the first ten years (1955-1965) and then, although NSF funding continued, became overshadowed by a new social mission and national emergency that was more urgent during the second decade (1965-1975).

Students. The major goal of this history-making investment of professional talent and fiscal resources, or the "bottom line" as economists might say, was to guide talented youth toward choices of careers in science. How well was this goal met? Welch cites a report to the National Science Board:

> "The college majors chosen by National Merit scholars provide some evidence that the situation has improved. Between 1966 and 1976, the proportion of scholars choosing science or engineering as a career rose from 62% to 70%. Since 1972 the percentage choosing science has declined six percentage points, but there was a balancing increase in engineering percentage points of eight points." (18)

Inquiry and Critical Thinking. And what about inquiry and critical thinking, those goals which were so important to the scientists who helped develop the new science programs? From the literature this is difficult to answer, perhaps because inquiry and critical thinking were outcomes difficult to measure or even define. There is little or no evidence that inquiry or critical thinking was assessed on nationally normed tests, a fact that is surprising in view of scientists' generally persistent efforts and commitment to measurement of other natural phenomena. In this regard, NSF efforts failed to complete the third link necessary for a more lasting curriculum change: (1) the development of new programs, (2) training for teachers using the new programs, and (3) changes in prestigious standardized tests to reflect changed student outcomes from the new programs. Therefore, when accountability for instructional resources and outcomes increased in importance during the early 1970's, the failure of science educators to publish acceptably reliable measures of inquiry and critical thinking may have contributed to the disappearance of activities that attempted to develop these skills in science classrooms across the country. But once again, that's getting ahead of the story.

Achievement. If inquiry and critical thinking were difficult to measure, achievement in the more traditional aspects of science

curriculum was much easier to measure and is discussed in great detail. Approximately one million college-bound students who took the ACT test (American College Testing) each year as a college entrance requirement performed better on the science portion of the test than they scored on the test as a whole. And while overall students' achievement as measured by the ACT Comprehensive scores (English usage, Mathematics usage, Social Studies reading and Natural Science reading) declined between 1964 and 1974, students' achievement in science remained relatively stable and in fact showed a slight increase. (19)

But more people worried about a report that appeared in 1975 by the National Assessment of Educational Progress, which suggested that among all of the students they surveyed, including college-bound and non-college-bound, there was a decline in students' knowledge of facts, concepts and principles in science. People appeared to ignore the results of the ACT tests and the fact that the primary target group of NSF had been the college-bound. (20)

Teachers. Few previous reformations in American education had affected the lives of so many teachers in such a short period of time. A conservative estimate of the number of science teachers who participated in some NSF teacher training activity during the Great Reform can be

derived from two sources: Welch noted that during the peak years of teacher training, 1960-1970, more than 16,000 teachers annually participated in NSF training. Helgeson cites a report that surveyed the number of science teachers in the United States in 1963 and found 103,666 teachers who taught one or more periods of science per day. Thus, in ten years 160,000 teachers could have been trained, even though records show that many teachers attended more than one workshop or institute, others retired during the normal course of events, and new teachers were hired. (21)

Teachers' behaviors changed: they overcame some subject-matter deficiencies and acquired new skills and methods. Surveys showed that administrators, science and math supervisors and teachers alike agreed that the classroom teacher was the single most important factor influencing instruction. Yet very little research actually focused on what teachers did while teaching science in elementary and secondary school classrooms. This turns out to be an important point to keep in mind when one reads the third section of this essay; it is tempting to think of Stake & Easley's case studies as descriptions of "after" in a before-and-after study. (22)

Classrooms. Were science and math classrooms different during the Great Reform, in the eyes of the chroniclers of the day? Textbooks

were still regarded as being more important as a teaching aid in 1965 than any other teaching aid. And 30%-40% of the teachers still taught science as lecture-reading or lecture-discussion, but there was an increase in the use of lab or activity-centered learning. Did the majority, the 60%-70%, replace their lecture-reading-discussion methods with an inquiry or learning-by-doing approach? This point is not clear from the literature available. (23)

There are, however, clues to this question if one looks at the materials teachers used. The new NSF science programs were widely implemented. For example, the BSCS high school biology program was used by about 40% of the students taking biology in the United States in the early 1970's, a time when most states reported that 80% of their students took high school biology sometime before they graduated. Likewise, the CHEMS high school chemistry program was used by about 30% of the students studying chemistry in the early 1970's; and the PSSC high school physics program was used by about 30%-40% of the students studying physics at that same time. (24)

There were many other programs at all levels of school, but based on these three science programs alone (BSCS, CHEMS, and PSSC), a conservative estimate might be that some NSF science programs could have been found in about one

of every three science classrooms in the country during the early 1970's. For mathematics, about 30% of the school districts surveyed in 1976-1977 said that they had used one of the federally funded math programs at some time during the reformation period between 1955 and 1975. (25)

But just having NSF textbooks did not guarantee that money would be available to buy the additional equipment and supplies which made inquiry or learning-by-doing possible. Surveys indicated that the lack of adequate equipment and supplies was a major barrier to teaching science. Yet information about the amount of money actually spent for science during that period is apparently not available: an annual national average of 11¢-14¢ per pupil was spent for elementary school science in 1965; an annual national average of $1-$3 per pupil was spent for high school science in 1973. Approximately 55%-65% of the schools surveyed used federal funds to help purchase science equipment and supplies in the early 1970's. But from the meager amount of information available, it is impossible to know how much was spent by schools on science and math materials during this period of history. (26)

One might infer that teachers, excited by their NSF training at a summer institute, returned to their schools and purchased the text-

books and teachers' guides which were the core of the program; but when or if funds were not available to also purchase the equipment and supplies, their excitement about teaching science as inquiry could not survive.

Teachers are part of a total school community. Those within this community - teachers, administrators and others concerned with school programs - can usually agree upon educational objectives by merging the views of experts and non-experts; but educational objectives are meaningless without the resources to implement them. People vote with their budgets, and they express de facto support of objectives through the amount of money they allocate to each program within the total school budget.

Therefore, any assessment of the impact of the Great Reform in science and math education must somehow take into account whether teachers who had received NSF training and had purchased course materials developed with NSF funding were also able to purchase the equipment and supplies that were needed to implement the inquiry approach of the new NSF programs.

Enrollments. Enrollments in science and math classes increased significantly between 1955 and 1975, but because the total school population also increased at that time, it was difficult for those concerned with instruction to

make comparisons as they attempted to assess the impact of the NSF programs. By 1975 the National Center for Educational Statistics in Washington, D.C. published a report showing the changes in total school enrollments and enrollments in science and math classes. Helgeson's analysis of information about students taking science courses in grades 10-12 indicated an increase of about 5% from 1955 to 1973, and a small reduction in percentage of students taking science courses during 1974-1976. (27)

In the next section, Table 1 will show the actual enrollments during this period of history and the percentage of students taking specific science courses. When Helgeson's data are reanalyzed by comparing them with more recent information from Weiss' survey, the fuller positive impact of increased enrollments in science courses becomes clearer.

Side-Effects. There was a great legacy in the NSF science programs themselves. Yet there were side-effects too. After the teams of scientists, teachers and others completed writing and field-testing the final versions of their science programs, commercial publishers negotiated for rights to publish them, and continued thereafter to be influenced by the design of the NSF programs. A whole new genre of hybrid science programs appeared on the market which "bore the distinct mark of a textbook science program"

but nevertheless were a new kind of textbook with greater emphasis on inquiry, critical thinking and "hands-on" activity than any of their antecedents prior to the NSF programs. Many of the new hybrids also reflected the important contributions made by educational psychologists in terms of organizing instruction to fit learners' levels of understanding or ways of knowing, designs that had guided the NSF programs. (28)

A Mission Overshadowed

Then things began to change. Just as Watson's paper on "The Critical Years Ahead" had sounded the Call to Arms that heralded the beginning of the Great Reform in science and mathematics education, and Sputnik had provided the visible symbol to justify the allocation of millions of dollars for the improvement of instruction in science and math, likewise, the voices of John F. Kennedy, Martin Luther King and Robert Kennedy called for a war on poverty and inequality. Their tragic assassinations within a single decade provided the visible justification for allocating billions of dollars toward economic and educational equity programs. When these three American heroes of human rights were shot, the expectations and aspirations of low income and minority citizens were threatened; and racial tensions, demonstrations and violence increased in major cities.

A concerned American public demanded responsible action from its leadership. By 1964, Congress approved the Economic Opportunity Act which focused on economically disadvantaged and school dropouts, and in 1965 enacted the Elementary and Secondary Education Act which provided massive support (over $1 billion per year) to create services for children and youth who came from low income families or other conditions which handicapped their educational opportunities. (29)

Although the National Science Foundation continued to support pre-college teacher training and curriculum development in science and math during the decade from 1965-1975, as the new social mission was launched in American schools and in society - the Human Rights movement - NSF gradually reduced its support.

Thus, without fanfare the science education movement was gradually and completely overshadowed by the Human Rights movement as astronomically greater amounts of money, concern and energy were poured into the new social reform in American schools.

As school districts across the United States undertook desegregation, thousands of students, teachers and administrators became the infantry of social change. Some discovered that they had to forego the historic primary mission

Figure 2. Without fanfare, the science education movement was gradually and completely overshadowed by the human rights movement as greater amounts of money, concern and energy were poured into a new social reform to be implemented by American schools.

of teaching and learning in many schools in order to merge students' culturally diverse traditions. Survival values which had been distilled and had endured through generations among these previously separate cultural groups came into conflict. (31)

It was a new experience for everyone. Teaching and learning were affected in ways no one had anticipated as students were grouped in classrooms to reflect the racial-ethnic composition of the community served by each school district. Many teachers and students who wanted to see racial integration succeed tried to ignore individual differences in students' academic needs when they interfered with the more important social mission; but these persistent differences could not be ignored in classrooms as readily as they could be in busses and restaurants. (31)

Students found their scholastic expectations thwarted as they were given instructional tasks that were out of tune with their previous experience; and teachers found it difficult to apply their finely-tuned skills to groups of students with such dissimilar academic preparation. (31)

Administrators and teachers alike felt they were faced simultaneously with three demands: to usher in a new social reform, to develop new in-

dividualized instructional programs that met the diverse needs of students, and at the same time answer cries for "relevance" from community groups. Without preparation or training, it was an overwhelming set of demands. (31)

By the early 1970's, critics began to voice concern over the decline in achievement test scores, seemingly unaware of or unsympathetic to the antecedents of the decline. Some teachers left their chosen profession, exhausted from the demands and frustrated that they could not maintain former achievement levels. (32)

Within the decade (1965-1975), the critics' cry for "relevance" in the classroom changed to a cry for "accountability" and back-to-basics education. The value-oriented programs were shelved and competence-based or performance-based programs which needed to be developed were the next task that teachers had to take home at nights and on weekends. (33)

The climate within schools gradually changed between 1965 and 1975 in ways that were antithetical to the goals and objectives of the original science programs; these changes had nothing to do with the Human Rights movement or equity programs. Rather, inquiry and critical thinking were asserted to be luxuries which could no longer be afforded with the new emphasis on accountability, competence-based pro-

grams, and recall of facts and principles. In fact, science itself was judged to be a luxury that could not be afforded time in many elementary schools. (34)

During the early 1970's it was a common experience for those who visited inner-city schools and talked with teachers who had formerly enjoyed teaching elementary school science, to hear teachers explain apologetically that they didn't have time to teach science now because they had to bring up the reading, math and language scores. (35)

Science teachers who were frustrated by these new demands for accountability and individualized programs in science asked for guidance; but by this time NSF had cut back its funding severely. (34)

Thus, as the end of the third quarter of the twentieth century came into view, many who were concerned about the status of science education in schools urged the National Science Foundation to assess the severity of the situation. In the summer of 1976, the three studies reviewed here were commissioned by NSF.

Section 2
A CROSS-COUNTRY VIEW

The second of the three NSF studies asked "how?" and "how much?" were science and mathematics being taught in American schools in 1976. Like a cross-country flight that stops briefly at intervals across the United States, this study surveyed the opinions of adults in approximately 400 school districts from 102 different geographic regions throughout the nation. (36)

Following questions posed by the National Science Foundation, Iris Weiss sent carefully tested questionnaires to 6378 teachers, 1417 principals, 488 superintendents, 2634 district supervisors and 192 state supervisors of science, math and social studies. Through novel and persistent efforts, Weiss received completed questionnaires from approximately 80% of the people contacted. (37)

What were the results of the survey? In a report of about 500 pages, Weiss describes the course offerings, instructional methods, curriculum materials, and qualifications of teachers and other staff, and summarizes factors which might have affected instruction in science and math in 1976-1977.

The brief summary of some of her findings that follows, when combined with the historical

background provided in Section 1, adds a new dimension to understanding the status of science and math education at the end of the third quarter of the twentieth century in the United States.

The amount of time spent teaching science and math in elementary schools appeared not to have declined, although Weiss reminds readers that all of her results are based on self-report surveys. Elementary teachers estimated that they taught science between 20-30 minutes per day and devoted between 40-50 minutes per day to teaching mathematics. This amount can be compared with the amount of time devoted to reading: about 95 minutes per day at the primary level (Kindergarten to grade three) and 65 minutes per day at the intermediate level (grades four through six). (38)

To many who had been concerned about the observed lack of science in elementary classrooms, it came as a surprise to find that teachers' estimates of time spent in science in 1976 matched amounts reported in 1965. Yet, the close parallel between teachers' estimates of their own behavior and district guidelines was not so surprising; most district guidelines in 1976 recommended a minimum of about 20-30 minutes per day for science and 30-40 minutes per day for math at the elementary level. (39)

At the high school level, time spent teaching science is translated into courses taken by average students. Most state guidelines for secondary school in 1976 required more than one year of social studies for graduation, while requiring only one year of math and one year of science for graduation. (40)

The most commonly offered courses in secondary school science were General Science, Biology, Chemistry and Physics, just as had been the case for twenty years. New courses emerged with an ecological or environmental orientation, reflecting changes in national concern for the environment. (41)

In secondary school mathematics, the most commonly offered courses were General Mathematics, Elementary and Advanced Algebra, and Geometry, again replicating the traditional titles; but the emphasis and content may have changed and new courses appeared with a statistical and computer orientation, again mirroring society's concern for application. (42)

Enrollments in science and math classes generally continued to increase, it appears, if the results of Weiss' 1976-1977 survey are added to the results reported by Helgeson, et al., for 1960-1961 and 1972-1973. It is always risky, of course, to combine information from two sources, and this is certainly true for documents about

enrollments, since different methods of surveying are frequently used. Readers may recall George Bernard Shaw's remark that the historian is safe if he has only one document to rely on, in difficulty if he has two, and hopeless if he has three. Fortunately, only two documents were necessary for the synthesis of Helgeson's and Weiss' enrollment data presented in Table 1.

Table 1 shows the actual number of students enrolled in four of the most commonly offered science courses in secondary schools in 1960-61, 1972-73 and 1976-77. Because the total school population increased during these years, Table 1 also shows the percentage of change (increase or decrease) in enrollments in science classes, compared with the percentage of change in the total school population.

Biology, for example, increased 61% in student enrollment between 1960-61 and 1972-73, compared with a 46% increase in the total school population. Likewise, Biology enrollments continued to show only a slight increase of 3% by 1976-77 while the total school population increased at a rate of about 2%.

Not shown in Table 1 is the increase in number of students entering high school prior to 1960-61. In 1948-49, enrollments in these four classes were: General Science - 1,121,980 (in-

TABLE 1: SECONDARY STUDENT ENROLLMENTS IN SCIENCE COURSES IN 1960, 1972 AND 1976

	1960-1961 (Grades 9-12)	1972-1973 (Grades 9-12)	% Change	1976-1977 (Grades 10-12)	% Change
Total School Enrollments	9,617,000[a]	14,077,000	+ 46.0%	14,321,000	+ 2.0%
Science Course Enrollments	(b)	(b)		(c)	
General Science	1,826,087	1,096,020	- 40.0%	1,338,637	+ 22.0%
Biology	1,776,306	2,868,352	+ 61.0%	2,953,466	+ 3.0%
Chemistry	774,820	1,028,591	+ 38.0%	1,196,140	+ 16.0%
Physics	402,317	583,105	+ 45.0%	511,611	- 12.0%

(a) Total School Enrollments (except % change) are from Helgeson, et al., 1977, p. 10.
(b) Science Course Enrollments for 1960-1961 and 1972-1973 (except % change) are from Helgeson, et al., 1977, p. 27.
(c) Science Course Enrollments for 1976-1977 (except % change) are from Weiss, 1978, pp. 58-61. Enrollments include General Science, Grades 9-12, Biology I, Chemistry I, and Physics I from Table 27. Because Weiss reports data as Grades 7-9 and 10-12, only Grades 10-12 have been used for Biology, Chemistry and Physics. Thus, increases in enrollments between 1972 and 1976 are actually greater if Grade 9 enrollments were available and could be added. Likewise, if Biology II, Chemistry II and Physics II enrollments were included, changes between 1972 and 1976 enrollments would be +14.0%, +30.0% and -3.0% respectively.

creasing by 63% in 1960-61), Biology - 995,930 (+78%), Chemistry - 412,401 (+81%), and Physics - 291,473 (+38%), according to Helgeson. (43)

Enrollments in secondary school mathematics courses also continued to show an increase for this same time period. Table 2 is presented in its original form from a report to the National Science Foundation prepared by the National Council of Teachers of Mathematics.

What materials and methods were teachers across the country using for science and math instruction in 1976? Generally, the textbook was still an important teaching aid, just as Helgeson had found reported in 1965, and more teachers preferred using a single textbook or program to using more than one. Most teachers used classroom discussion as their primary method of teaching, and preferred to lecture more often than they offered students "hands-on" or laboratory activities. Laboratory requires preparation time and time for use of equipment. With budget cuts teachers often have more classes, little time and thus low incentive for labs. Table 3 shows the percent of classes having teachers who used these various materials and methods. (44)

Because inquiry, critical thinking and finding out things for oneself are usually associated in science with having materials to ex-

TABLE 2: COURSE ENROLLMENTS IN SECONDARY MATHEMATICS FOR 1972-73 AND 1976-77 (IN THOUSANDS)

	1972-73	1976-77
General Mathematics 9-12	2417	2563
Business Mathematics 9-12	392	609
Elementary Algebra	2052	2825
Advanced Algebra	1808	1317
Geometry	1506	1900
Trigonometry	171	460
Probability/Statistics	25	39
Computer Mathematics	63	153
Advanced Senior Mathematics	259	225
Calculus	55	105

(Source: Fey, James, p. 5)

TABLE 3: TEACHERS' USE OF MATERIALS AND METHODS: SCIENCE & MATH

	Science	Math
Teachers Using a Single Text or Program	49%	63%
Teachers Using More than 1 Text/Program	33%	32%
Teachers Using Lecture: Just About Daily	26%	46%
: At Least 1/Week	37%	21%
Teachers Using Discussion: Almost Daily	50%	71%
: At Least 1/Week	35%	16%
Teachers Using "Hands-On" or Laboratory Materials: Just About Daily	13%	14%
: At Least 1/Week	35%	24%

(Source: Weiss, 1978, pp. 89, 102-103.)

plore, a closer look at the use of science and math materials that can be manipulated reveals some interesting facts. Table 4 shows the frequency of classes which used manipulative materials in science and math, by grade level.

What becomes immediately clear in Table 4 is the fact that students were given the opportunity to use manipulative materials to learn more frequently in science, with each grade level, but less frequently through the grades in mathematics. Since a great deal of research has shown that some first-hand experience with objects is essential for learning abstract concepts in math and science, it seems likely that students had a better chance of understanding math than science in elementary schools in 1976, and were more likely to understand science than math in high schools.

It was not surprising to find that teachers who had attended one or more NSF teacher training activities were considerably more often found using manipulative science materials with their students than teachers who had not attended the NSF sessions. (45)

About half of the senior high (grades 10-12) science teachers reported they still used the NSF-funded science programs in 1976 When one considers the longevity of use of the NSF-funded programs, especially within the context

TABLE 4: FREQUENCY OF CLASSES USING MANIPULATIVE MATERIALS IN SCIENCE AND MATH, BY GRADE LEVELS

	K-3rd Grade		4th-6th Grade		7th-9th Grade		10th-12th Grade	
	SCI.	MATH	SCI.	MATH	SCI.	MATH	SCI.	MATH
Almost Daily	7%	29%	11%	9%	24%	5%	12%	6%
At Least 1/Week	30%	37%	25%	25%	37%	16%	60%	8%
Totals	37%	63%	36%	34%	61%	21%	72%	14%

(Source: Weiss, 1978, pp. B 56-63.)

of American consumerism and the frequency with which many citizens trade in homes, cars and appliances all costing more than textbooks, ten or more years' use of textbooks by 50% of the population seems like an excellent return on an investment. (46)

Elementary and junior high school teachers used the NSF materials somewhat less frequently than their colleagues in senior high schools: approximately 35% of the junior high school classes and between 20%-30% of the elementary classes were still using the NSF science programs, according to districts reporting to Weiss' survey. It is important to keep in mind that elementary schools were the primary target for many of the new equity programs (such as Bilingual, Right to Read, etc.), which began in the mid-sixties and increased in amount of categorical funding through the seventies. (46)

The new math programs did not fare so well. Less than 9% of the districts surveyed were still using the NSF-funded math programs although about 30% of them had used "new math" at some time before. (48)

Teachers who had attended NSF training were found in great numbers. Almost half of the senior high school science teachers who answered the survey had participated in NSF training activities at some time in the past. (They may

have been the ones using the NSF textbooks, but that isn't clear.) One wonders whether the high percentage of NSF-trained teachers might be linked to the increase in length of teaching career; the average increased from 8 to 12 years during this period. (47)

About one-third of the junior high school science teachers had received NSF training, while one in twelve teachers of 4th-6th grades and only one in fifty primary teachers of Kindergarten-3rd in 1976 had previous NSF training.

Thus, it became obvious through Weiss' survey that the amount of time spent on science in elementary schools, and the amount of continued use of NSF science programs at all grade levels, as well as the amount of "hands-on" or laboratory activity offered in classrooms at all grade levels - all of these were closely linked to whether or not teachers had received NSF-sponsored training. Moreover, it was equally obvious that the impact of the NSF training had had a very long-lasting effect, as evidenced by the continued use of methods and materials introduced to teachers as much as 12 years earlier. It is quite remarkable that so many teachers held onto the goals of their earlier training, in view of the major social changes that took place during the decade ending in 1976. By 1980, school climates have stabilized considerably, and one wonders whether these teachers

might not again wish to pick up where they left off teaching science as a process of inquiry, perhaps with a booster session or two.

The most serious problems facing science teachers were those related to fiscal resources and teaching methods or materials. Inadequate facilities, insufficient funds for purchase of equipment and supplies, and lack of students' interest in the subject or ability to read were considered "a serious problem" or "somewhat of a problem" for the majority of science teachers answering Weiss' survey. (49)

There was welcome evidence that school climates had stabilized somewhat; discipline was not generally a serious problem; teachers generally viewed themselves as being adequately prepared to teach their subjects and having colleagues in math and science who were interested in their subjects. (49)

Rather, teachers' needs were for assistance in learning new methods and obtaining information about instructional materials. They wanted improvements in the availability of lab assistance or paraprofessional help, equipment and supplies, and space - for storage of equipment, for preparation of materials and for working with small groups of students. (49)

What were the prevailing attitudes toward science and math among students, their parents or community members and school administrators in Weiss' survey? Were these individuals satisfied with science and math instruction in schools in view of some of the "bad press?"

Questions such as these may have prompted the NSF to support the series of case studies below as the third part of their assessment of science, mathematics and social studies in the United States in 1976.

Section 3
A CLOSE-UP VIEW

Phrases like "seeing is believing" and "walk in another man's shoes" convey the sense of trust people have in their own perceptions of events, and may account in part for the great popularity of the case studies compiled by Robert Stake and Jack Easley. (50)

If one wishes to find out "what's really happening in science or math instruction in this country," logic tells us, "go out into the schools: visit the classrooms; sit in the teachers' lounge and in the principal's office; stand in line at the bus and in the cafeteria; listen to the conversations of students, teachers, administrators and custodians; go to the

PTA and School Board meetings to hear what parents and community leaders have to say. Then you'll know," logic tells us.

Responding to such logic, Robert Stake and Jack Easley invited highly experienced researchers to live in eleven carefully chosen school communities across the United States, representing the rural, suburban and urban; north, south, east and west; racial and economic diversity; innovative and traditional fiber of American schools.

After spending from 4 to 15 weeks in a particular school community, each researcher prepared an ethnographic description which was preserved intact as part of the final collection (Volume 1) of Case Studies in Science Education (50). Stake & Easley then prepared Volume 2, a thoughtful analysis of the eleven case studies and sketched a composite which was really a description of "multiple realities" rooted in people's different perceptions and reflected the richly textured fabric of science and math education found in this vast country.

To present here the results of their study and still preserve the character of the case studies themselves, original conversations and observer reports are used as much as possible in this section, with brief commentaries added where necessary to highlight a key point or two

along the way.

The first close-up view contains observations that illustrate the highly individualistic climate that characterized every school. The uniqueness of a school's climate or identity is particularly evident in the comparison of two schools which appeared to be the same in every way but location. Within this same close-up view one also sees the difference in perception, expectation and behavior of individuals within the same school, a timeless reminder of the individuality of human beings.

The presence of these two forces within schools illustrates an important point. Whatever conclusions are drawn about the status of science and math instruction in this country must somehow take into account the influence of these two forces upon every student: on the one hand is the predominant climate within the school which affects students' understanding of and attitudes toward science and math, and on the other hand is the variability of teachers within the school, which can in a single case have a significant impact on what students learn in their science or math classes.

To capture the essence of one school climate, consider the racially mixed urban high school along the Northeast coast described by Rob Walker, a visiting ethnographer from Great

Britain:

> "...the school...occupies a new ten-floor building....Parking is a nightmare....Once inside, you lose much sense of what lies outside. It's one of those things that is so obvious to all the teachers that they have long since ceased to question it..... Pete /ā science teacher there/ feels it is not so much an architectural feature of the school but a feeling of belonging, of familiarity and recognition. Once inside school, he feels secure; he likes to be there. Enough teachers feel the same way that it is not something they need to talk about, or feel the need to hide....To someone whose image of an inner city is one of hostility or human desolation, it no doubt seems strange that a good many of the teachers, and some students, feel at home here." (51)

By way of contrast, Rudolpho Serrano's description of a Western community shows how different a school climate can be in a similar racially mixed urban high school. He heard a science teacher explain:

> "'Students cut classes quite often and the administration doesn't seem to care. The classes meet only fifty-five minutes a day for four days a week with one day that

floats. When you get students wandering around the hallways and out on the grounds at all hours of the day, you know the administration doesn't give a ____....' /Serrano adds./ This concern was voiced by a large number of faculty members with greater frequency than was concern over supplies, equipment or adequate reading materials." (52)

Seemingly small events helped to crystallize the differences between these two school climates. In the Northeastern coastal city, Rob Walker reported:

"During homeroom Mr. Henry /the principal/ picks up the phone in his office and dials into the school intercom so as to read the morning announcements. 'Congratulations to the chess team....Would the basketball team report to the gym at one p.m.' Part way through, his assistant adds some more notes to the pile and Mr. Henry switches to Spanish. When he had finished he called to the assistant, 'Hey, next time give me some warning about that. My pronunciation is rusty, especially the numbers.'" (53)

When Serrano commented on a similar situation involving use of a second language in the Western urban high school, he recalled the principal's reaction to the state-mandated plan to

develop a bilingual program for the school's 40% Chicano population:

> "If you start with one language, where will it end? There are so many languages that people speak around here. We have Basques, Filopinos, Native Americans, Germans, etc. Where are we going to get the teachers to teach these youngsters? It's insane to ask the schools to do all of these things." (54)

Once aware of a school's climate, an awareness which often creeps up unexpectedly after listening to many conversations, it suddenly seems important to hunt for some individuals who somehow are an exception to the predominant climate. Serrano's description illustrates the difference between two science teachers. The first exemplifies the predominant climate; the second illustrates the exception to the norm.

> "Biology...is taught in the traditional way. The teachers prefer not to use the BSCS materials exclusively for fear that the students would not understand them.... The course...resembles the old...variety of the fifties. It is interspersed with some basic materials but only sparingly." (56)

> "The /P̄hysics̄/ class was performing a laboratory experiment. They were working

> with the ripple tanks studying wave reflections and refractions. The class appeared engrossed with what they were doing....They also appeared to be well informed about what they were doing and the theory behind their experiments. /Their teacher/ , however, is leaving at the end of this academic year. He is going to work for a private industrial firm." (55)

The contrast in two schools' identities which emerged without Walker's or Serrano's intent could be found between any two of the case studies one chose to read. Likewise, every case study had its own contrast among members of the school population, just as Serrano found the physics teacher who excited students and was planning to leave at the end of the year, in sharp contrast to the predominant pattern of 1950's biology classes.

The next close-up view is a miniature but representative collection of conversations and observations which illustrate a second major theme found in the case studies: that while there were some instances of excitement and vigor in elementary school science, generally elementary science education suffered from serious neglect due to unavoidable constraints placed on teachers.

In a rapidly growing suburb of Houston, Terry Denny may have smiled when he heard a parent who was an electrical engineer say:

> "Someone is teaching my daughter a lot of good astronomy. She eats it up. I am amazed at what she is learning in the second grade!" (57)

And in the same district, Denny heard a kindergarten teacher say:

> "We have two hours and forty-five minutes in an instructional day. Science takes time. /I̲ teach̲/ a little science before the school's science fair each year. I'll let the first grade do science." (58)

The first grade teacher in Denny's report commented:

> "First graders love science. It is exciting and different....When my first and second graders get excited about science -- magnets are fun, you know -- they squeal with delight." (59)

And from a parent in a rural Illinois school, Alan Peshkin heard:

> "The /s̲cienc̲e̲/ fairs give kids an incentive to delve deeply. I know my daughter

studied DNA. She wrote quite a paper; learned many things I didn't know." (60)

But the predominant pattern was illustrated by Gordon Hoke's observation in a small city in Pennsylvania:

> "Science instruction is 'on the back burner' in the elementary grades." (61)

This concern was reported in a major metropolitan community of the Pacific Northwest where Wayne Welch observed:

> "Only on occasional /elementary/ teacher or principal who is interested in the area... /science/generates interest that may spread throughout the building. Otherwise, one is most likely not to see any science at the elementary level." (62)

Similar reports came from many field researchers. A description by Serrano summarizes the familiar pattern:

> "The science program at the elementary school...is almost non-existent....This is somewhat surprising because in 1972, the local state university initiated an NSF Elementary Science Program for teachers.... For various reasons the elementary schools appear to be giving up the science programs

that numbers of them had established a few years earlier....Of all the schools visited, five years after the state project was started there was only one school that was utilizing one of these programs." (63)

After careful analysis of the eleven case studies, Stake and Easley concluded:

> "Although we found a few elementary teachers with strong interest and understanding of science, the number was insufficient to suggest that even half of the nation's youngsters would have a single elementary school year in which their teacher would give science a substantial share of the curriculum and do a good job of teaching it." /Underlining added for emphasis./ (64)

Mathematics at the elementary school level did not appear to be suffering from neglect, but had clearly changed in substance. Denny's description of elementary school math in the Houston suburb is typical of the swing back to traditional mathematics:

> "Almost to the teacher there is a sigh of relief that the 'modern math god' is dead." /And for K-12 teachers math meant/ ... "learning the 100 basic facts of the four arithmetic operations." (65)

When asked if this wasn't a move back to basics, one teacher replied:

> "Back /to basics/? We never left!" (65)

Stake and Easley concluded:

> "In the eleven districts /case studies/ we found little evidence of 'new math'....Instead, various forms of paper-and-pencil mathematics dominated the scene in the elementary schools." (66)

It is not difficult to understand why science had all but disappeared from the elementary school classroom, or why math had returned to the traditional basic facts and operations. But it was somehow less tolerable to see "hands-on" experiences disappear from classrooms where English was not the predominant language spoken. Serrano captured the sense of loss when he listened to an elementary teacher refer to a student who sat isolated from the others, in a school that was 40% Chicano:

> "/He/ just arrived from Mexico. We have him sit over there because no one can understand him. He hasn't learned to speak English yet. When he gets to the point where he can understand English, we'll start him on math and some of the other areas." (67)

The third close-up view portrays some of the characteristics of science and mathematics instruction in American high schools in 1976. From the conversations and observations in science, one senses the "multiple realities" Stake and Easley found; math appears to have had more of a "single reality." Both science and math were accorded serious attention by those concerned about high schools.

In Houston's suburb, Terry Denny reported:

> "Among all academic subjects taught in high school, science occupies a special place ....It posseses an aura of favor, acceptance; and responsiveness to it seems greater than that of other subjects." (68)

And in that urban high school of the Pacific Northwest where 55% of the students go on to college, Wayne Welch noted:

> "Probably 80% of the class time is spent by students working on experiments; and three different tracks (developed locally) are provided, depending on students' ability." (69)

Another high school located in the well-to-do suburb of a large metropolitan city of the Midwest, with a reputation as an outstanding prep school, was described by Lou Smith:

> "...[the] high school's curriculum guide looks like the catalogue of a small college: 12 math courses, 12 courses in science in two sequences for college bound and non-college bound...." (70)

At a rural high school in Illinois, Alan Peshkin heard the high school science teacher comment:

> "Today there's less interest countrywide in science than there was when I first started teaching. There's less of a push to be a scientist and more to be a technical person because they make more money." (71)

In this same school district, a school board member said:

> "I never took a foreign language. I doubt that my daughter in high school will need a foreign language in later life. Math is tops, I guess, because it's important in my business -- electrical work and farming. I can't see a person go through life without math....I think this is the Board's point of view." (72)

The high school counselor of this same Illinois high school held a different view:

> "People are turned off by math because they think it's harder than other subjects. They

can say about a course like Biology, 'O.K., I'll get this and I'll relate it to being on a farm.' But if they get to Advanced Math without a goal for using it, they can't relate to it." (73)

Sameness was the predominant pattern within the math classroom in nearly every case study. Wayne Welch's description of the math classrooms of Hardy High School could serve as the classic:

"Conventional textbooks...are used in most classes....In all math classes I visited the sequence of activities was the same. First, answers were given for the previous day's assignment. The more difficult problems were worked out by the teacher or a student at the chalkboard. A brief explanation, sometimes none at all, was given on new material, and the problems were assigned for the next day. The remainder of the class /period/ was devoted to working on the homework while the teacher moved about the room answering questions. The most noticeable thing about math classes was the repetition of this routine." (74)

Wasn't this routine boring? Recall that Weiss found "lack of students' interest" a major concern of about 30% of the high school math teachers (grades 7-12) and somewhat of a concern for another 43%-53% of high school math teachers.

(75)

On the issue of boredom in math, Stake & Easley commented:

> "In most of our sites we found secondary school mathematics to be just as traditional and work-oriented as learning to compute in elementary school. The judgment from mathematicians and other visiting site observers was that many of the courses were tedious. Several noted, however, that students in high school mathematics classes did not appear to find them as dull, uninspiring, and irrelevant as the observers did. Teachers and students appeared to accept mathematics as a dry mechanical thing, to be done stoically." (76)

In the last close-up view of the nature of science and mathematics instruction in American schools in 1976, the focus is on how well the spirit of inquiry survived, since inquiry was such an important idea to the scientists who helped develop the NSF science programs ten and twenty years before. If one searches through the case studies for inquiry, it's there in a few places. They are among the most eloquent examples of teaching, in the minds of some readers. For example, in an Eastern middle seaboard city school, Jacquetta Hill-Burnett observed a deliberate and thoughtful emphasis on how peo-

ple, including scientists, might come up with ideas, about how knowledge is formed, how ideas are created and how phenomena are explained. In a junior high school, a teacher started the discussion with the question:

> "'How many saw Venus last night? Who wants to draw where they saw Venus?' (He gets two quick volunteers.)....'What was the phase of the moon?' Three students drew their observations on the blackboard. They compared their representations with each other and with sketches other students had made. Questions arose about the nature of the phenomena of moon phases versus the question of how to represent what is happening. They agreed, with the participation of the teacher in the discussion, to observe and record their observations once again that night in order to answer some of the questions raised in the discussion. /Next/ Mr. Nicollet introduced material from the textbook, then said: 'Look, this book is out-dated now. It was published in 1974. When did we land on Mars?' (pause) ...'The information in this book is inaccurate because these were guesses....Don't believe something because it's in a book. /Just because/ information is in books means nothing. Believe your experience!'" (77)

Inquiry still survived in an elementary school in a Houston suburb where a Kindergarten teacher said, "Reading about yeast does not equal making bread," and another one said, "The /child's/ question means curiosity and that means opportunity for learning -- not for getting what's in me to him." (78)

But in other classrooms in the same school a more common pattern was observed. In a discussion of rainbows as an example of reflected and refracted light, the science teacher was frustrated because he felt he could not answer the students' questions:

> "Mr. Parker, why does it hang together?"
> "Why does what hang together?"
> "A rainbow. I mean, why don't we see a whole bunch of three-colored spots in the sky instead of a band?"
> "That's hard to explain. You just don't know enough yet to explain that. But keep thinking. That's a good question."
> /When the teacher later admitted to the reporter that he felt that no matter how much he prepared, students' questions would still reveal his inadequacy, he said to the reporter:/
> "So I just keep up with yesterday and let tomorrow take care of itself." (79)

The need for training in the inquiry pro-

cess was made apparent in this last example, especially when it is compared with the former example of the junior high school teacher who talked with students about Venus. The brief dialogue below between two math teachers provided a sad commentary on teachers' attitudes toward inquiry in 1976:

> "I give half credit to students whose work is correct but who do not use the right method."
> /And the other said in response:/
> "A lot of times they may be able to figure out the answer; but if they don't know the method, they...haven't really learned anything." (80)

One senses that students tried to adjust to a world of "right" answers in that school. A seventh grade student was learning to cope when she said:

> "The problem is learning which teachers like which kinds of answers. Some want them exactly from the book. If they aren't exact, 'That's sloppy thinking,' says Ms. X. Mr. Y says you really don't know it if you can't put it in your own words. Now, Ms. X is right because just any old words won't do for telling about, let's say, atomic stuff. And Mr. Y is right because when I really know it I can say it in my

own words. But it's all mixed up and it is hard to tell sometimes which is right,.... So you better know what teachers' answers are or you will get graded down a lot." (When asked if other kids knew this she responded) "All /the kids in the top level/ know this." (81)

Stake & Easley looked back over the eleven case studies and summarized their conclusions about the status of science and mathematics education in the United States in the year 1976-1977: Science was being given low priority in schools while basic skills were receiving increased emphasis; science faculties in high schools still worked hard to protect courses for the college-bound (sometimes prerequisites and "tough" grading kept these classes small); reading about science was the predominant pattern in elementary schools; math and science were taught at all grade levels as subjects defined by "what experts said" and inquiry was seldom seen as a process of knowing in science; rather the textbook was usually seen as the authority on knowledge and it served as the teachers' guide as well as the students' guide to learning. (82)

Section 4
CONCLUSIONS AND COMMENTARY

One underlying theme emerges from these three very different studies. The reformation in science education which took place in the third quarter of the twentieth century had a major and dramatic impact on science teachers, their students and classrooms across the United States - an impact which peaked in the midyears between 1950 and 1975. An equally important part of that theme is that the impact of this reformation in science education was overshadowed by an even greater social reform of tidal wave proportions, the Human Rights movement which began in the mid-sixties and involved more money, more teachers and more students.

The magnitude of the reformation in science education was obvious in the historical view derived from an analysis of the literature and documents written during this period. More than 160,000 science teachers in the nation probably experienced the excitement of science as a process of inquiry into the nature of the universe and living things in it, and rediscovered how knowledge in science is formed. These teachers must have transmitted their excitement to their students because students enrolled in science classes in greater numbers than could be expected from the population increase alone. And these students demonstrated their superior

science achievement on college entrance exams. More National Merit Scholars than before chose to major in science as they continued their education at colleges and universities. There were more innovative science programs available than ever had been seen by the teachers then teaching. And these programs could be found in about one of every three science classrooms in the country.

But $650 million invested by the National Science Foundation to support this reformation could not produce miracles. It did not prevent a decline in national test scores which measured rote learning of scientific facts and principles among non-college-bound along with college-bound. Neither could $650 million provide teachers with all of the equipment, supplies or space they needed to implement their new science programs. Nor could science as inquiry and learning-by-doing survive in a back-to-basics, competence-based curriculum environment.

The impact of NSF's short-term $650 million simply could not compete with the impact of the Human Rights movement whose yearly budgets for programs exceeded the entire twenty-year investment from NSF.

The magnitude of the impact of the reformation in science education could also be seen in the cross-country view presented here from a

national survey of school people's opinions and practices, and in the close-up view of what happened on a day-to-day basis in American schools in 1976-1977 as reflected by eleven case studies.

Like aftershock patterns that follow an earthquake, the evidence of the former magnitude was there. Teachers who had participated in NSF training could still be found; they showed up among half of the high school teachers surveyed in 1976, and NSF-funded science programs were still used by about half of all secondary science teachers polled.

But inquiry had barely survived; and although "hands-on" and laboratory activities could be found, teachers throughout the nation said they were in need of equipment and supplies. In elementary schools across the country, science suffered from serious neglect in the eyes of first-hand observers. Teachers and administrators responded to the demands of their local school districts and the state which in turn reflected what was viewed as a national trend toward accountability and emphasis on basic skills.

The single conclusion that stands out most clearly and boldly from the three studies of the status of science education during the third quarter of the twentieth century can be stated

very simply: Excellence in science education was attained when it was important enough to society; but mediocrity returned when concern was withdrawn.

The image which remains in the minds of those who participated in the reformation in science education is one where scientists, teachers and others talked enthusiastically about what could be, and then tried out their ideas in classrooms. The best understood knowledge about how children and adolescents learn and develop was combined with the most advanced knowledge in science to produce custom-made science programs for the youth of the nation. In that image is contained a picture of millions of American students learning about science the way scientists learned about it.

It is not surprising that science education on our nation's 200th birthday looked very much like it had a quarter of a century earlier, or in fact, like the catechetical science lessons from the early 1800's; public schools in the United States are responsive to public pressure and social change. And the primary concern of America in 1976 was that its high school graduates could demonstrate proficiency in basic skills. Science was and is not considered a basic skill. The concern for basic skills was totally understandable in the historical context of the 1960's and 1970's. Between 1952 and

1970 the percentage of students who attended public school for 12 years increased from 50% to 75%; and a major goal of the equity programs included efforts to improve the basic skills of students who had formerly dropped out of school before graduation from high school. (83)

But one thing is disturbing. Given the Human Rights movement and America's historic fight for intellectual freedom, it is disturbing that teachers should receive more public pressure to present the science textbook as the source of authority than to develop students' competence and confidence in their own ability to think critically about science related problems.

Moreover, at a time in the world's history when the most valuable skills or traits may be the capabilities to ask intelligent questions, think critically and imagine new solutions, it is equally surprising that the public values most in science a demonstration of students' stored-up knowledge of what scientists have thought in the past, rather than students' capacities to solve problems.

Yet the fact remains that science educators failed to develop effective measures of inquiry and critical thinking for standardized tests; and this fact contributed to the deemphasis of inquiry and critical thinking from science

classrooms, when school administrators and the public became more concerned about accountability for instructional resources and outcomes.

One of the important questions the public now faces with regard to science education in schools is whether Americans are adequately preparing youth for the year 2000 A.D. We must ask ourselves if it is in the best interest of our offspring and the world to teach science primarily through reading, as a history of science, rather than as a way of knowing and solving problems.

It is a difficult decision for informed citizens to make. And because most citizens will not have time to read the seven volumes of NSF studies which describe the status of science, math and social studies education in this country, most will depend upon summaries or commentaries of the studies written by spokesmen. In this regard, one last point needs to be made.

Since the NSF studies were published in 1979, a few spokesmen, the minority, have drawn the conclusion that the reformation in science education was a failure, a flop. It is important to take a moment to understand the basis for this negative view because it can have some serious consequences. (84)

A close inspection of most negative views reveals that their owners fail to distinguish between the current status of science education in this country and the status of science education during the 20-year period of funding. It is a view that fails to account for the impact of the movement before it was overshadowed by the Human Rights movement. This view could be called the "bottom line view" because, like the economist, it looks at the $650 million NSF investment as a 20-year investment with a 1976 maturity date. The problem with the "bottom line view" is that it equates success or failure with the end product rather than with events throughout the entire movement.

The consequences of this view will be described in a moment but first it is important to examine the false assumption underlying the view. Many people assume that schools are more or less static as an organization, perhaps because they want schools to be stable and endure. But schools are elastic organizations: they respond to all pressures, not just pressure from a single source such as parents, school board members, district or state mandates, or federal support or cutbacks. The "bottom line view" assumes that the benefit of the $650 million should still be visibly intact in the form of benefits to schools. But that view ignores all of the other pressures that teachers, students, administrators and other school people face.

The science education reformation did not happen in a vacuum.

What are the serious consequences of the view that the reformation in science education failed, that "the NSF curriculum reform movements of the 1960's...were not very successful," as one spokesman concluded, or that "for all the talk and all the dollars, neither the content nor the method of teaching...has changed that much in the past twenty years," as another spokesman wrote? (84)

Four consequences can originate from this limited view and can compromise the future of science education in a serious way. First, members of Congress and the general taxpaying public are very unlikely to continue support for a mission that appears to have failed, especially if members within the professional ranks believe that the mission failed. It would be less embarrassing if the charge came from outside rather than from within. The result of this "bottom line view" can be a disabling loss of fiscal support and public trust.

Second, the thousands who participated in the development of the new science programs and teacher training, if written off as a failure, are unlikely to devote more energy to a similar task or encourage others along these lines. The result can mean a serious loss of existing and

future professional talent and commitment needed to improve science instruction.

A third consequence of the limited focus of impact is that it has temporarily blinded others from looking for further impact or effects. It is unlikely that anyone will expect or search for evidence of great things that might come from the most talented of that population of students who were exposed to twelve years of science and math as a process of inquiry. Many of these students should be finishing graduate school just now and be ready to make their contribution to the world. Those concerned with the "bottom line" may not be looking at the "real bottom line."

At least one more serious consequence could occur from the NSF-no-impact view. Individuals in the future who will try to improve science or math education may be led to reject ideas about how to develop curriculum, teach science or math, or train teachers, simply because past effort was viewed as a failure. Reasonable people would be more likely to try something else. It is not an argument to keep things the way they were, but an argument to avoid mislabeling ideas.

If any of these four outcomes were to occur based on the conclusion that the reformation failed, it would be an inexcusable loss. The

error of focusing on a particularly small point in time and ignoring the historical context of science and math education between 1950 and 1976 could be very costly in terms of lost fiscal support and public trust, loss of professional talent and commitment, failure to look at the "fruit in season" graduates of the reformation, or the rejection of ideas about teaching science mathematics and education.

The last quarter of the twentieth century has already begun. Certainly the way science and math are taught in schools will be influenced by the great reformation that took place between 1950 and 1975. But the importance and status of science and math in schools are determined to a great extent by a relatively small number of informed citizens.

Excellence in science education was attained during the third quarter of the twentieth century, at a time in our nation's history when science was important. But by America's bicentennial birthday, science education had become mediocre in many schools and in a state of serious neglect in others. Have Americans underestimated the importance of preparing American youth to make intelligent decisions about the world they will manage in the year 2000? It will be a world which requires a better understanding of science and how new knowledge in science is formed and used, not less - and

nothing less.

FOOTNOTES

1. Bartlett, Montgomery R. Common School Manual, Utica, N.Y.: Northway & Bennett. 1827.

2. Welch, Oliver, American Arithmetic, Boston: Lincoln, Edmands & Co. 1834, pp. 199 and 204.

3. Stake, Robert and Jack Easley, Jr. Case Studies In Science Education, Executive Summary, National Science Foundation: 1978, p. 19:6.

4. Stake & Easley, op. cit., p. 13:40.

5. Welch, Wayne W. "Twenty Years of Science Curriculum Development: A Look Back," Review Of Research In Education, 7:282 (1979).

6. Rutherford, F. James The Status of Pre-College Science, Mathematics and Social Studies in Educational Practices in U.S. Schools: An Overview and Summaries of Three Studies, National Science Foundation, 1978, Foreword.

7. Helgeson, Stanley, Patricia Blosser and Robert Howe The Status of Pre-College Science, Mathematics and Social Science Education: 1955-1975, Volume 1: Science Edu-

cation, NSF, 1977.

8. Weiss, Iris R. Report of the 1977 National Survey of Science, Mathematics and Social Studies Education, National Science Foundation, 1978.

9. Stake, Robert and Jack Easley Case Studies in Science Education, Volumes 1 & 2, and Executive Summary, National Science Foundation, 1978.

10. In order to disseminate the findings of the three NSF Status Studies, the NSF invited nine national professional organizations to review and interpret the NSF Status Studies for their respective memberships. These organizations, the titles of the interpretive reports and their authors are cited individually in appropriate places.

11. Watson, Fletcher G. et al. "Critical Years Ahead in Science Teaching" In Helgeson, et al., op. cit., p. 118.

12. Welch, Wayne W. op. cit., p. 286.

13. Welch, Wayne W. op. cit., p. 283; and Helgeson, et al., op. cit., p. 92.

14. Helgeson, et al., op. cit., pp. 16-17, 22-23, 180-182.

15. Helgeson, et al., op. cit., pp. 259-260 provides a glossary of the acronyms for all of the NSF curriculum projects cited.

16. Helgeson, et al., op. cit., pp. 44-45.

17. Quick, John. Film: Don't Tell Me, Let Me Find Out, Science Curriculum Improvement Study, Lawrence Hall of Science, University of California, Berkeley, 1971.

18. Welch, Wayne W. op. cit., p. 298.

19. Helgeson, et al., op. cit., pp. 114 and 172-174.

20. Helgeson, et al., op. cit., p. 114.

21. Helgeson, et al., op. cit., pp. 20, 34-36, 75-77.

22. Helgeson, et al., op. cit., p. 81; and Welch, Wayne W. op. cit., p. 283.

23. Helgeson, et al., op. cit., pp. 32-34 and 84.

24. Helgeson, et al., op. cit., pp. 26-28.

25. Weiss, Iris R. op. cit., p. 79.

26. Helgeson, et al. op. cit., pp. 33 and 38-40.

27. Helgeson, et al., op. cit., pp. 25-27.

28. Helgeson, et al., op. cit., p. 23.

29. Helgeson, et al., op. cit., p. 139.

30. Helgeson, et al., op. cit., p. 140.

31. Helgeson, et al., op. cit., pp. 43, 56, 161-164, 192. Also the present author worked with master teachers, student teachers and their students in ten urban city school districts in the San Francisco Bay Area throughout 1965-1977 when desegregation was introduced into the Berkeley schools and categorically funded programs were introduced in all ten school districts.

32. Many teachers in the San Francisco Bay Area objected to ABC's 60-minute television program on prime time, American Schools: Flunking the Test on May 27, 1976 because it lacked any understanding of the causes of schools' problems. Also Helgeson, et al., op. cit., p. 115.

33. Helgeson, et al., op. cit., p. 152.

34. Helgeson, et al., op. cit., pp. 114-116, 152, 140.

35. The author's experience cited in 31. above.

36. Weiss, Iris R. Survey, pp. 1-9.

37. This survey utilized a national probability sample of districts, schools and teachers. The sample was designed so that every superintendent and principal, and every teacher and supervisor of science, mathematics and social studies in grades Kindergarten through 12 in the U.S. had a chance of being selected: Weiss, I.R., Survey, p. 16, and Executive Summary, p. 1.

38. Weiss, Iris R. Survey, pp. 49-51, and Executive Summary, pp. 12-14.

39. Weiss, Survey, pp. 20-22, and Executive Summary, p. 23.

40. Weiss, Executive Summary, p. 22.

41. Weiss, Survey, pp. 57-60, and Helgeson, et al., p. 21.

42. Fey, James T., J Kilpatrick, C. Tobin and H. B. Tunis, Mathematics Teaching Today: Perspectives From Three National Surveys, National Council of Teachers of Mathema-

tics, 1979, pp. 5-6.

43. Helgeson, et al., op. cit., p. 27.

44. Weiss, Survey, pp. 89, 102-103.

45. Weiss, Executive Summary, p. 19.

46. Weiss, Survey, pp. 82-83.

47. Weiss, Survey, pp. 69-70; Executive Summary, p. 11; Helgeson, et al., p. 191.

48. Weiss, Survey, pp. 78-79.

49. Weiss, Survey, pp. 143-149, B-93-100, B-106-115, B-125-128; Executive Summary, pp. 16, 22-24.

50. Stake & Easley, op. cit., Vols. 1 & 2.

51. Stake & Easley, op. cit., Vol. 1, pp. 11:2-3.

52. Stake & Easley, op. cit., Vol. 1, pp. 7:27-28.

53. Stake & Easley, op. cit., Vol. 1, p. 11:21.

54. Stake & Easley, op. cit., Vol. 1, p. 7:5.

55. Stake & Easley, op. cit., Vol. 1, p. 7:25.

56. Stake & Easley, op. cit., Vol. 1, p. 7:27.

57. Stake & Easley, op. cit., Vol. 1, p. 1:21.

58. Stake & Easley, op. cit., Vol. 1, p. 1:26.

59. Stake & Easley, op. cit., Vol. 1, p. 1:28.

60. Stake & Easley, op. cit., Vol. 1, p. 4:6.

61. Stake & Easley, op. cit., Vol. 1, p. 10:10.

62. Stake & Easley, op. cit., Vol. 1, p. 5:9.

63. Stake & Easley, op. cit., Vol. 1, p. 7:6.

64. Stake & Easley, op. cit., Executive Summary, p. 19:3.

65. Stake & Easley, op. cit., Vol. 1, p. 1:18.

66. Stake & Easley, op. cit., Vol. 2, p. 13:18.

67. Stake & Easley, op. cit., Vol. 1, p. 7:7.

68. Stake & Easley, op. cit., Vol. 1, p. 4:5.

69. Stake & Easley, op. cit., Vol. 1, p. 5:4.

70. Stake & Easley, op. cit., Vol. 1, p. 3:40.

71. Stake & Easley, op. cit., Vol. 1, p. 4:9.

72. Stake & Easley, op. cit., Vol. 1, p. 4:5.

73. Stake & Easley, op. cit., Vol. 1, p. 4:5.

74. Stake & Easley, op. cit., Vol. 1, p. 5:6.

75. Weiss, Survey, p. B-126.

76. Stake & Easley, op. cit., Vol. 2, p. 13:23.

77. Stake & Easley, op. cit., Vol. 1, p. 9:6.

78. Stake & Easley, op. cit., Vol. 1, pp. 1:24-26.

79. Stake & Easley, Vol. 1, p. 4:45.

80. Stake & Easley, Vol. 1, p. 1:47.

81. Stake & Easley, Vol. 1, p. 1:57.

82. Stake & Easley, Vol. 2, Preface.

83. Helgeson, et al., op. cit., p. 156; and the Panel of School Science, Commission on Human Resources: The State of School Science (National Research Council: National Academy of Sciences, National Academy of Engineering, Institute of Medicine), June, 1979, p. 29.

84. Smith, Herbert A. A Report on the Implications for the Science Community of the Three NSF-Supported Studies of Pre-College Science Education, American Association for the Advancement of Science, June, 1979; and also Shannon, Thomas A., Math, Science, and Social Studies Curriculum: Retrospect and Prospects, National School Boards Association, 1979, Foreword.

SOCIAL SCIENCE EDUCATION IN THE UNITED STATES

1955-1975: A BRITISH PERSPECTIVE

A review by

Lawrence Stenhouse*

University of East Anglia

---

*Lawrence Stenhouse was educated at Manchester Grammar School and the Universities of St. Andrews and Glasgow. After teaching in secondary schools in Glasgow and Dunfermline, he spent four years on the staff of the University of Durham before becoming Head of Education in Jordanhill College of Education, Glasgow. In 1967 he became Director of the Schools Council and Nuffield Foundation Humanities Curriculum Project. Subsequently he has directed a program of research on Problems and Effects of Teaching about Race Relations supported by the Social Science Research Council (of Great Britain) and the Calouste Gulbenkian Foundation; a project on Problems in the Dissemination of Action Research supported by the Social Science Research Council, and a Project on Library Access and Sixth Form Studies supported by the British

Library Research and Development Department. He is Professor of Education and Director of the Centre for Applied Research in Education in the University of East Anglia, Norwich, England. His books include Culture and Education and An Introduction to Curriculum Research and Development, and he has recently edited Curriculum Research and Development in Action. A member of the Norwegian Academy of Science and Letters, he has been Council of Europe Visiting Professor in the University of Uppsala, Sweden and Nicolaysen Fellow in the University of Oslo. He has also lectured in the United States, Canada, Australia, New Zealand, West Germany, and Austria.

INTRODUCTORY

Under review is an inquiry sponsored by the National Science Foundation in an attempt to get a picture of the state of science, mathematics and social science education in United States Schools. The inquiry was commissioned in 1976, and the reports reviewed date from 1977 to 1978.

The reviewer is British. His experience lies in curriculum research and development in the area of human issues and race relations and in the descriptive case study of educational institutions, and he has had some responsibility

for the dissemination of MAN: A Course of Study in the United Kingdom. His brief is to concentrate on the social science area.

OVERVIEW OF THE INQUIRY

The N.S.F. strategy was to fund three sizeable projects -- a survey, a review of literature and a multi-site field study -- which worked in parallel to capture three different perspectives on the situation.

The Survey

The survey (SE-78-72) was designed on classic lines. Questionnaires were administered to a sample of teachers and educational administrators asking for reports on practice and for opinions and judgements. This part of the inquiry was conducted by the Research Triangle Institute of North Carolina and Directed by Dr. Iris Weiss. Separate questionnaires were developed for teachers of mathematics, of science and of social studies, for school principals and for administrators at school district and at state levels. The Request for Proposal from the N.S.F. (which defined science to include the natural sciences, the social sciences and mathematics) directed the survey to the following questions:

1. What science courses are currently offered in schools?

2. What local and state guidelines exist for the specification of minimal science experiences for students?

3. What texts, laboratory manuals, curriculum kits, modules, etc., are being used in science classrooms?

4. What share of the market is held by specific textbooks at the various grade levels and subject areas?

5. What regional patterns of curriculum usage are evident? What patterns exist with respect to urban, suburban, rural and other geographic variables?

6. What 'hands-on' materials, such as laboratory or activity centred materials, are being used? What is the extent and frequency of their use by grade level and subject matter?

7. What audio-visual materials (films, filmstrips/loops, models) are used? What is the extent, frequency and nature of their use by grade level and subject area?

8. By grade level, how much time (in comparison with other subjects) is spent on teaching science?

9. What is the role of the science teacher in working with students? How has this role changed in the past 15 years? What commonalities exist in the teaching styles/strategies/practices of science teachers throughout the United States?

10. What are the roles of science supervisory specialists at the local, district and state levels? How are they selected? What are their qualifications?

11. How have science teachers throughout the United States been influenced in their use of materials by Federally-supported in-service training efforts in science?

The questionnaires used in the Survey were designed to elicit factual data, such as sex, qualifications and experience of the respondent; self-report about such matters as acquaintance with curriculum materials, teaching practices and use of information and support services; judgements or opinions about contextual factors and material provisions affecting teaching; and

expressions of need for help or support. The questionnaire has limitations associated with pre-ordinate questionnaire design: it does not in its alternatives cover some of the issues which were found to be of interest by the review of literature and/or the case studies. For example, the problem of teaching controversial issues is not included either in the question on problems or that on needs for assistance. In fact the range of questions is rather 'shallow', though useful within limits. Moreover, the self-report element in the questions on use of teaching methods and on time spent on various subjects and activities introduces a considerable risk of distortion. In spite of design controls and control items, a strong element of judgement remains in the interpretation of responses to such questions. At the same time, it must be conceded that there is a force to knowing 'what a teacher either does or would like to think s/he does', since responses which are indicators of that kind reveal quite well the presence of a pressure of norms.

In the purely technical sense the questionnaire design and sampling were satisfactory. Response rates were as follows:
State Supervisor 90%; Superintendent 73%; District Supervisor 72%; Principal 84%; Teacher 76%. (SE-78-72-Table 1-p.16).

A substantial body of data emerges from a survey of this sort. No attempt is made in this review to provide a summary. The summary provided by those responsible for the survey in SE-78-71 is - just - adequate. Unfortunately the major survey volume lacks an index.

The Literature Review

The second study used modern search techniques and manual supplementary searches or supplementary inquiries within the 'invisible college' to review and analyze the literature on existing practices in schools and in teacher education for the period 1955 through 1975 and on needs assessments, local and national. This study was mainly the responsibility of a team from the Center for Science and Mathematics Education of the Ohio State University, but the social science component, which is the main concern of this review (SE-78-73Vol. III) was sub-contracted to the Social Science Education Consortium of Boulder, Colorado, and headed and reported by Karen B. Wiley and Jeanne Race.

The 'major areas of concern' in which they 'sought and found information on practices, effectiveness and needs' were:

1. Social studies curriculum scope and sequence

2. Social studies instructional methods

3. Social studies curriculum materials

4. Social studies teacher education.'

(SE-78-73, Vol. III, p.3).

The reviewers claim to have included in the social science review a total pool of 2,000 to 2,500 documents and they cite 505 of these in their bibliography. In addition to their discursive review summary they offer tabular analyses of knowledge, attitude and skills objectives proposed for social studies in the period 1955-1975 and outlines of the scope of content coverage of social studies in the same period. They also present in tabular form a rather broad content analysis of social studies texts, certification requirements in social science for elementary and secondary teaching and data on achievement testing in social studies.

The evidence which can be drawn from a literature search has the limitation that it reflects concerns rather than practice and much of the review was based upon review articles since otherwise the volume of literature would have been impossible to handle. The strength of the literature review is in its breadth and in particular its capacity to reflect trends of thinking and concern over a span of years. It fills

in much more firmly than either survey of field study can the intellectual history of social studies over the twenty years 1955-1975.

Again this review will not provide a summary. That offered by the authors of the review (in SE-78-71) is adequate in its coverage though this reviewer would have welcomed an approach to condensation closer to that of the historian of ideas. What we are given are lists of trends and findings. Again there is no index in the master volume (SE-78-73-Vol. III).

The Field Study

The observational field study is the most innovative of the three approaches though it belongs in a long tradition. William Cobbett, for example, wanting to know more of the state of agriculture and the countryside in early nineteenth-century England, saddled his horse and rode out to observe for himself, and produced from his observations the classic field study, Rural Rides (1830).

No need in this case for horses. Robert Stake and Jack Easley of the Center for Instructional Research and Curriculum Evaluation and the Committee on Culture and Cognition of the University of Illinois at Urbana-Champaign employed a network of observers who examined closely a collection of cases chosen to cover

the main variables expected to influence science education. Each of the eleven cases comprised a high school and its feeder schools. The collection aimed at diversity and balance: 'rural and urban; east, west, north and south; racially diverse; economically well-off and impoverished; constructing schools and closing schools; innovative and traditional' (SE-78-71-Introduction to C.S.S.E.). The task of the observers, who spent four to fifteen weeks on site, was to produce case studies usable for the purposes of comparison and survey by the directors of the project. Site visitations by consultant groups checked out their rapidly gathered group impressions with that of the case study worker. Finally, the researchers turned to a random sample of about 4000 teachers, principals, curriculum supervisors, superintendents, parents and senior class students, and used a questionnaire to confirm the findings of the case studies and to add special information.

The Request for Proposal from the N.S.F. for this part of the study directed the field study to the following questions:

1. What are the perceptions of the role, scope and function of science education at the local level as identified by students, teachers, parents, administrators, and supervisors?

2. What roles are played by parents, teachers, students, school board members in the review, selection and use of science curricular materials?

3. What practices exist in the selection and use of curricular materials?

4. What are the roles of the teacher in the science classroom? How effectively do teachers perform these roles? What are their qualifications?

5. What objective evidence is available about the effectiveness of science education programs as measured by student outcomes?

6. How and by whom are science teachers and students evaluated?

7. What laboratory materials were used in connection with science curricula?

8. What out-of-school resources are used in conjunction with science curricula?

9. How much time (in comparison with other subjects) is spent on the teaching of science at different grade levels?

10. How effective are the science education efforts as viewed by students? by parents? by teachers? by administrators?

11. What special efforts are set aside for those students skilled or highly interested in science? for non-reading or unmotivated students?

12. In comparison with other subject matter, what budgetary considerations are given to the teaching of science?

13. What types of local in-service training programs exist? How often are they conducted? by whom? What is the level of participation? How effective are they as perceived by teachers?

14. What supervisory positions exist for science at the district and school level? What function is served by personnel who fill these positions?

15. How are science education programs administered? By whom? What are the administrators' qualifications?

16. What barriers exist to improving science education at the local level as perceived by students, teachers, administrators, school boards, supervisors, parents?

17. In what ways do the major issues, questions or concerns identified differ by subject matter (science, mathematics, social studies)? by grade level within subject matter?

The summary report briefly addresses each of these questions, but the field study, since it is by design responsive to the ideas of those personnel in the school system who were interviewed and to the perceptiveness of the field observers, ranges much more widely than the questions and indeed specifically discusses possible N.S.F. responses to the situation it portrays.

The writers of the executive summary of the field study clearly condense with reluctance. 'Having already partially mutilated the delicate and complicated portrayals of happenings and feelings as drawn together by our field observers by attempting to sort and aggregate them in our findings chapters, we now further over-simplify by presenting them in grand summary' (C.S.S.E.-19-1).

In the event, what it amounts to is that the conclusions survive as the evidence is progressively eroded. Whereas we turn to the fuller account of the survey to verify results or to seek more results, we turn to the individual case studies to modify the summary and to understand how things actually were. And, indeed, there are passages where one would want to debate whether the evidence justifies the summary, and passages where summary is interpretive or recommendatory in a more radical way than the summaries of the other two studies. Of course, that makes it better reading.

There are those who, confusing calibration with objectivity, would regard the methods of the field study as more subjective than those of the survey. On the other hand, one could argue that the questionnaire of the survey was less well-founded on patient observation than that of the field study and hence more subjective. Perhaps the most useful distinction between the two strategies is caught by saying that the survey asks us to judge its results by a critical scrutiny of its methods while the field study asks us to judge its methods by a critical study of its results. This means that we lose the capacity to respond critically to the survey to the extent that the information about its procedures is compressed, while it is the compression of results - or perhaps 'reports' would be better -- that weakens our hold on the field

study. And certainly the vividness of the case studies both engages attention and tests conviction.

CONTEXT

The context for the whole study lies in the recent history of curriculum research and development and the N.S.F.'s role in it. As F. James Rutherford, the N.S.F.'s Assistant Director for Science Education, writes in his foreword to the volume of overview and summaries:

> There can be no question about it:
> The two decades of activity in science and mathematics education that began in the mid-fifties are unique in the annals of American education. Under the leadership of the National Science Foundation scientists and educators were mobilized in an unprecedented effort to strengthen science and mathematics learning from elementary school through the post-doctorate (SE-78-71, Foreword).

The effort of the National Science Foundation expressed itself in the production of classroom materials, the preparation of teacher handbooks, the support of evaluations and the provision of in-service institutes for teacher education.

These activities are not scrutinized individually, nor are they enumerated and described: rather they are assumed and placed in the context of the question: 'What was the lasting outcome?'.

The initiative behind this movement of curricular reform or renewal in science and mathematics is often popularly associated with the shock of Sputnik, but in fact it began rather earlier and affected most western countries. Whatever the reasons -- and they must be quite complex -- those scientists and mathematicians who became attached to the idea of updating the teaching of these subjects in schools by bringing the school subjects more into harmony with the spirit of the university disciplines found during the two decades from 1955 to 1975 that they could get access to financial support.

The opportunities for well-supported development were perhaps always greater in mathematics and natural science, probably because of their reputation for practicality and perhaps because of their status as difficult studies yielding secure knowledge. But in a period of relative affluence and optimism substantial sums were invested also in development in social sciences and in those areas of biology bordering on the social sciences. The questionnaire used in the Survey lists twelve sets of 'selected social studies curriculum materials' at elementary lev-

els and twenty-one at secondary levels. These are characteristically materials produced by projects as contrasted with a large number of textbooks produced by private venture authors for publishers.

The curriculum reform movement impacted on a controversy in social studies teaching which was not paralleled in mathematics and the physical sciences. The question is whether the social studies should be an induction -- some would say socialization -- into society and its social and political values or an induction into the academic disciplines of history, geography and the newer social sciences. In the end this tends to express itself less in terms of general knowledge versus academic knowledge than in the opposition of facts entwined with traditional wisdom to facts structured by theory. The theoretical view of knowledge invites speculation and values questioning. It lessens the weight of tradition on the future. It democratizes the privilege of scepticism. It is continuous with the spirit which led Socrates to fall foul of his fellow citizens.

The reassessment of the epistemological basis of schooling urged an early grasp of knowledge as a matter of concepts, models, theoretical structures, and skills of thinking with them. The thrust was towards admission during the years of schooling into the medium of think-

ing which Jacques Barzun has called 'intellect':

> Intellect is the capitalized and communal form of live intelligence; it is intelligence stored up and made into habits of discipline, signs and symbols of meaning, chains of reasoning the spurs to emotion - a shorthand and a wireless by which the mind can skip connectives, recognize ability, and communicate truth. Intellect is at once a body of common knowledge and the channels through which the right particle of it can be brought to bear quickly, without the effort of redemonstration, on the matter in hand....intelligence wherever found is an individual and private possession; it dies with the owner unless he embodies it in more or less lasting form. Intellect is on the contrary a product of social effort and an acquirement. (Barzun, 1959, pp. 4-5)

The old way of acquiring access to intellect led through a long apprenticeship during which knowledge was being stored rather than used. Knowledge disseminated through instructional teaching was largely 'inert,' to use Alfred North Whitehead's characterization. It was a burden on the mind, but those who bore it patiently and industriously would in due course find it beginning to turn into intellect. Those who persisted long enough would emerge from

tutelage as an elite for whom knowledge was volatile: not dangerously so, of course, at least for the most part, for the long apprenticeship served to socialize the greater number of those who passed through it into acceptance of the intellectual and social status quo.

The reformers saw the logical possibility of so grading intellect and problems that knowledge was learned by the exercise of intelligence on intellect from a very early age. If intelligence working on intellect was process working on content then in curricular terms process might profitably become content. But the volatile and adventurous aspects of intellect were exhilarating rather than reassuring: mountaineering offered to those who were used to railway journeys. It was necessary to 'legitimize the search' (MACOS 1970).

The means of disseminating knowledge must shift towards learning by discovery or inquiry: children would be more students, less pupils. Learning would take place by the learner engaging in research and independent study instead of, or as well as, depending upon authoritative instruction. Young people would come to understand how knowledge is built, and hence its status and limitations.

The change in teaching and in the culture of the classroom that this shift called for is

widely held to have been underestimated. It was so radical that experienced teachers found that they were novices again, burdened by often unexpected incompetences (MacDonald, 1973). The inapplicability of familar skills both troubled teachers' sense of identity and threatened their disciplinary control of the classroom until they became accomplished in the new style.

To complicate the process of transition there were superficial resemblances between child-centred progressivism and knowledge-based curriculum reform. Progressivism also stressed inquiry and creativity, originally in Dewey expressive of the epistemology of pragmatism but latterly softened towards personal development and motivation. The 'project' as a medium of school learning, which might be taken as characteristic of this progressive tradition, was commonly much less sensitive to the knowledge base than would accord with the spirit of the curricular movement. Yet the two were often confounded and in fusion spelt confusion.

The critical reaction to the knowledge-based tradition of the curriculum reform movement came from several different sources. Some believed that much knowledge should be accepted on authority: the authority of one's elders and betters, of experts or even, in the case of the creationists, of God. Others associated the school's control problems with the new styles of

teaching (which had in fact been less widely implemented than this would imply). Yet others believed that the schools' pursuit of knowledge led to neglect of the basic skills and useful information. Many who needed easy optimism just diagnosed the development as too difficult and gave up.

The voices of dissent, disappointment and disillusion reached the politicians, who had earlier heard those of optimism. A critical re-appraisal became a recoil; the recoil became a movement. Priests of the old faith recanted. 'Whatever became of all that investment?' the N.S.F. was asked. 'Better not spend any more money until you're clear about the needs.' It was no use then talking of the obvious problems of an attempt to get truth into the schools. Politicians, lobbies and public, like Pontius Pilate, would not stay for an answer to that one.

And so - or that is how this reviewer understands it - the National Science Foundation attempted this classic inquiry into the state of the nation. Though, of course, that story is not told in the inquiry itself.

What did they find out about social science in schools?

THE PICTURE WE GET

The reports are written with an American audience in mind, and there is consequently a good deal of tacit assumption which is not shared by a British reviewer. This review also is aimed primarily at American readers but assumes that a British reading will be of interest, not least for the entry angle it has to take to get into various topics.

It is a surprise to discover that requirements in social studies are apparently more widespread than requirements in mathematics. States commonly require specific courses in social studies: 83% as compared with 7% with requirements in mathematics and 8% with requirements in science (SE-78-72-Table 5-p.25). This seems strange to an outsider: most Europeans think of mathematics as more firmly established in the curriculum than social studies. Math is a core or basic subject.

However, the widespread requirement in social studies is not a sign either of status or of confidence in the subject area.

Thus, when reporting on the number of minutes devoted daily to math, science, social studies and reading in self-contained classes, teachers in K-3 assigned math 41 minutes, science 17, social studies 21 and reading 95. At

grade 4-6 level the figures were: math 51, science 28, social studies 34 and reading 66 (SE-78-72-Table 25-p.51; SE-78-71-Fig.6-p.14). Self-reports of the kind lying behind these figures are notoriously unreliable as objective accounts of classroom practice, but they should be fairly good indicators of teachers' judgements of the relative importance of subjects, and this in turn we should expect to influence practice.

Moreover, the picture of an elementary school concentrating hard on the mechanics of reading and, to a lesser extent, on math is confirmed by the case studies. A teacher's voice from the Fall River case study sums it up pretty well: 'We do math and reading in the morning when the kids are fresh. We do science and social studies in the afternoon if there's a chance' (CSSE-2-21). And there is some feeling, especially in regard to social studies, that cooperative working is given a chance. One teacher says: 'I feel science and social studies give us the one place in academic schooling when the lowest kid can really participate in class' (CSSE 1-35). The balance between science and social studies is partly determined, it would seem, by teachers lacking confidence in their capacity to teach science: evidence of this abounds in the case studies.

In the requirements for high school graduation very few states require specific courses in mathematics and science (presumably to avoid a higher barrier to graduation by students who are not academically inclined), while 83% require one or more - often more - specific social studies courses. However, the most commonly required courses are United States History (81% of districts), American Government (34%) and World History (17%) (SE-78-72-p.25-26). Thus the requirement is concentrated not in social science or even in general or integrated social studies, but quite specifically in history and predominantly in American history. The prescription is -- as, indeed, is traditionally true of history teaching in most countries -- nationalist. It is, in part at least, a means of teaching citizenship and of socialization. Participation in democratic process and hence access to power may be learned, but it is learned within a context which inclines to interpret citizenship as patriotism, and, most likely, patriotism as acceptance of the status quo.

Sociology, psychology, and anthropology are generally options when they are on offer at all. In Alte, for example, ninth grade social science with options in anthropology, state history or cultural history leads to a uniform Tenth-grade -- Foundations of Western Civilization and a range of 11-12 grade options including East

Asian Studies, Latin American Studies, American Legal System and Political Philosophy alongside a required course in American History (CSSE 3-39). In Fall River:

> The social studies curriculum... comprised of four government courses, two in sociology, six in American history, five in world history, five in geography, and one each in religion and philosophy. The program has no underlying and unifying principle (CSSE-2-11).

In Western City:

> In the social studies area - G.H.C. (government, history and civics), as it is more commonly called in the W.C.S.D. - a great variety of programs exist. This is brought about because every student in school is required to take G.H.C. every year that he attends junior high school. Consequently, every school has fifteen to twenty classes of G.H.C., and there are approximately four full-time teachers involved in the instruction of G.H.C. (C.S.S.E. 7-15).

In River Acres:

> The social studies in junior high school are the summation of three courses: world

studies in the sixth grade, geography and history of Texas in the seventh, and the first year of a two-year required program in U.S. history in the eighth grade (C.S.S.E.-1-51).

The social studies area appears to be dominated by history and, outside that, frequently reduced to civics. Geography -- surprisingly to a Britisher -- does not have a strong place. The social sciences -- sociology, anthropology and psychology -- are decidedly marginal. There is occasional political science.

Although social studies is usually an area of requirement, state prescription often leaves room for options, and even when specific courses are prescribed, they are open to interpretation. Influences, particularly the influence of teachers, can shape them. But the review of the literature observes that 'The scope and sequence of the social studies curriculum has remained relatively stable in general outline over the past twenty-year period', and though it goes on to suggest that 'there have been a few noticeable shifts within that framework such as the infusion of concepts and methodologies from the scientifically oriented social science disciplines' (SE-78-71-55-8), the trend of evidence in the report suggests that any ambitious move in that direction is likely to be blocked by a rising back-to-basics movement with an emphasis

on mindless skills.

The stability of the social studies curriculum can be partly described by reference to custom laying down sedimentary assumptions. Traditions develop, for example, associating certain content with certain years. We read that over the twenty years covered by the review of literature:

> Fifth-grade U.S. history appears to have come under the influence of a 'presentist' orientation in 1975, while in the earlier periods more or less traditional U.S. history topics were dominant (SE-78-111-30).

and

> The traditional sixth-grade focus on the Western Hemisphere is replaced in 1975 by a world cultures course, drawing heavily on social science content, especially from anthropology (SE-78-73III-30).

Eighth-grade U.S. history and tenth-grade world history are described as remaining 'basically the same' and 'fairly stable'.

The greatest fluctuation is ascribed to grades seven, nine, eleven and twelve. One trend in grade seven is 'a shift from early emphasis on regional studies....to an emphasis on broad themes, such as gaps between the rich and poor nations and national independence movements.' Grade nine offers 'various combinations of world geography, civics, world cultures, and state history'. 'The eleventh grade American history course has been transformed from one with a primarily political orientation to a study of many aspects of the country's social, economic and cultural development'. And 'the twelfth grade problems course has been replaced with a variety of social science courses, including sociology, anthropology, geography, economics, psychology and government'. At lower grade levels there seem to have been a shift from rural themes towards the urban, the cosmopolitan and the multi-cultural. (All these trends from SE-78-73, Vol.III, p.30-31).

Too much credence should not perhaps be placed on evidence of change culled from a search of the literature. However, experienced readers will be able to judge in which of these observations realities are so tinged with aspirations that their referent is the school in the sky!

The overall impression gathered from the survey, review and field study is that social

studies lack status and certainty of purpose in the American school system, though this is perhaps least true when it is academic history. As Terry Denny observed of his elementary school observations: 'I paid far less attention to elementary social studies than I did to science and mathematics. I believe the teachers did, too' (CSSE-1-34). It is partly held in place by legislative requirement at state or district level, though here, as in the school itself, it is vulnerable to the back-to-basics movement. Tradition also has an influence, no doubt strengthened by the fact that it brings insurance against insecurity. But its existence and its low status seem also to have a positive value and function in the school. It is seen as well adapted to mixed ability teaching and, if taught with character and some imagination, potentially high in interest value. In the face of reading difficulties it can be made accessible through film and discussion. Moreover, so long as it is not hardened off into social science, it is felt that a wide range of teachers can teach it. It consequently provides a flexible and accessible medium for the expression of cooperation and community in required courses and for feeding those who are not academically inclined in the option system.

It is dangerous for an overseas reviewer to put forward so risky a hypothesis as this, but I'm encouraged to believe that even explaining

why it is wrong may be a good exercise for an American reader. So I'll chance my arm and guess that if a few subjects like this didn't exist in schools we should have to invent them. Social studies in the elementary school can teach children what McGuffey and his like used to teach in the old-style readers, before they were mown down by word-counts and readability formulae. In the high school they offer a means of non-technical general education highly adaptive to differences of ability or interest. It is the force behind this utility that teachers intent on stiffening social studies have to contend with. So too the N.S.F.

Within this dominant tradition, how is information offered to students? Most importantly through the text book.

Approximately half of all social studies classes use a single published textbook or program. The most commonly used textbooks in social studies are:

K-6 Social Studies

Laidlaw Social Science Program (King)
Exploring Series
Social Sciences: Concepts and Values (Brandwein)
Contemporary Social Science Curriculum (Anderson)

7-9 American History

This is America's Story (Wilder)
America: Its People and Values (Wood)

10-12 American History

Rise of the American Nation (Todd)
History of a Free People (Bragden)

(SE-78-72-Table 43-p.92)

These texts are not familiar to a British reviewer. One can say only that the titles of the American history texts certainly appear to confirm that their general orientation is patriotic and celebratory: they do not signal - and signals are considered by publishers with an eye to the market - a discipline-based emphasis. The K-6 social science texts sound more open and more discipline-oriented. But here American readers will be ahead of the reviewer.

Information is lacking on materials use in a rather high proportion of classes, (16% of K-3, 13% of 4-6, 26% of 7-9 and 14% of 10-12), but use of texts seems to be heavier in grades 4-12 than in K-3. 35% of K-3 classes are known not to use texts. About 10% of grades 4-12 are known not to use texts (SE-78-72-Table 44-p.94). Of the classes using texts, 60% at K-3 use texts with copyright before 1971, the equivalent fig-

ures being 46% for 4-6, 27% for 7-9 and 31% for 10-12 (Figures computed by reviewer from SE-78-72-Table 44-p.94).

The picture that emerges for half the classes studying social science is of teachers building their courses round a textbook, which once adopted, is used for a considerable time. Presumably both financial considerations and teacher preference (perhaps partly out of familiarity) hold the established textbook in place. The majority of teachers seem to prefer the book or program they are using (SE-78-72-Table 47-p.100). Many publishers offer supplementary materials and these are used to an uncertain extent (SE-78-72-p.96-97) to build out the course. Many textbooks or programs have accompanying teacher manuals and these too are widely used. Teachers, principals and district-wide supervisors are heavily involved in textbook selection: students, parents and school board members have low involvement. This situation would be taken for granted in most countries, but has recently been sharply questioned in the United States.

The dominance of the single textbook is, however, by no means total. The following table shows the usage of one, two or multiple texts/programs and the proportion of schools using no text at all:

Percent of classes using none, one, two, and three or more textbooks/programs in social studies by grade range.

Number of Textbooks/ programs.	K-3	4-6	7-9	10-12	TOTAL
None	35	9	11	11	17
One	42	53	47	45	47
Two	7	20	19	22	16
Three or more	16	19	22	22	20

(Extracted from SE-78-72-Table 40-p.89)

What happens when no textbook is used? Or, for that matter, what happens in class when one is?

In the absence of textbooks it seem that for the most part teachers prepare materials of their own.

> One primary teacher had organized a very sophisticated package using the newspaper to introduce the children to society, even government and economics. One sixth-grade teacher gave a lecture on the functions of the three branches of government. After the material had been assimilated the

> students entered into a role-playing with teams of students acting out the roles of Senators, Congressmen, the President and the Supreme Court justices, going through the process of how a bill becomes law. (CSSE-2-21).

In a Texas Junior High School 'little use is made of textbooks in many of the social studies classes' and instead 'the students do 'packets' or short instructional modules created at local level (CSSE-1-51). The use of these packets is partly motivated by disenchantment with the alternative eighth-grade text - 'It is about college level'. (CSSE-1-51).

Derry's comment on these packages is worth quoting, because it catches well the sorts of ambiguities and of pressures evidenced again and again in the case studies.

> Depending on the informant, packets represent either 'stuff we have been using for years, but now redesigned into packets', or 'a new approach to the teaching of social studies'. Regardless of the informant, the packets apparently were created at great personal time-cost to the teachers. The packets are not the outcome of the.... district curriculum guide project, which was roundly panned by a majority of the teachers as a 'waste of my

time'. 'I should be spending time preparing to teach rather than writing those curriculum bulletins'. (CSSE-1-52)

Within the framework of self-created materials or of textbooks, the departures from the instructional classroom seem rather rare and to involve most often simulations or attempts at discussion, mostly of a kind dominated by the teacher.

But sometimes there is a radical departure from standard patterns. Lou Smith has this to say about the Alte Learning Resources Center.

> Briefly, we would note the L.R.C. contains: a storage area for the hundreds of work sheets in the IPI program (Individually Prescribed Instruction in mathematics); instructional aides who check materials done by pupils, keep records and dispense materials prescribed by the teachers; school-wide library resource (5,000-10,000 books in <u>each</u> elementary school library); and aides and volunteers who help out in this part of the center. In visits to the LRC's it was not uncommon to find half a dozen adults busy with children at any one time. The facility seemed to take on a life of its own; that is, its existence and the presence of creative teachers and district resources provoked a series of

alterations, additions, and elaborations. As audio-visual equipment was centralized, new programs in literature, e.g. tapes of stories, were developed. Listening and study carrels were added with tape players and earphones. Possibilities in spelling were seen and the Alte individualized spelling program was developed. Special reading teachers, working with individuals and small groups, found a home and became an active part of the LRC. (CSSE-3-15).

And then again there is the textbook leading the teaching, here being read aloud around the sociology class.

Mrs. F. begins reading from the textbook. The topic is explanations of cultural variation. Harry reads next. The other students sit quietly and follow along with the reader.

S: Is that far enough?

T: Please continue....O.K., this tells us that geographic factors do not explain cultural variations because we find different cultures in the same geographic area....(A student asks a question about some point in the text)

T: I don't know. Why don't you look that up?

T: Jill, will you read?

S: I can't.

T: Sure you can. Try.

S: I know I can't so why should I try?

T: Sure you can Jill. (Jill reads and does quite well). Thank you Jill. So it has a contributing effect, but does not explain the whole thing. Are cultural variations a product of race? Patty, would you like to read? (Patty reads) So we cannot rely on race as an explanation for why cultures vary. And geography's not the answer. All right. Let's see what follows. Ed, will you read? (He reads) Tim, please read....

As Stake and Easley put it in their overview: 'The role that teachers play in setting the purpose and quality of the science program was apparent in all our case studies and reaffirmed in our national survey' (SE-78-71-19-2). 'Teacher is Key' (SE-78-71-19-1). The message sounds through case study after case study. The

way to improve schooling is to help teachers to better their art.

THE NEEDS TO BE MET

The survey reports teachers' perceptions of their own needs. Some two-thirds of the teachers believe they need assistance in obtaining information about instructional materials and a like number want help in learning new teaching methods. Substantial minorities of teachers want help with the discovery/inquiry approach, with the use of manipulative materials, with small-group teaching and with obtaining subject matter information (SE-78-72-p.148-149). They do not need help with establishing instructional objectives, with lesson planning, with actually teaching lessons or with maintaining discipline (SE-78-72-Table 72-p.147).

Stake and Easley in their executive summary adopt the idea of developmental progress - taking a bearing on where you are and then trying to move on and up - rather than trying to get ahead by imagining where you want to be and working on a diagnosis of discrepancy. This seems sensible to this reviewer, and they put the point pretty well by analogy with the Jacobian procedure in mathematics.

They observe:

For example, it was our observation, and it might be concluded by officials of the NSF, that 'teacher support systems' were weak and needed vitalization. The teacher having difficulty carrying out an ordinary science teaching assignment was seen to be without sufficient aid, though many agencies existed for the purpose of providing aid. Teachers told us that their resource people largely did not know the realities of their classroom situations. Potential alleviations were seen via better curriculum materials, institutes for teachers, Teacher Centers, and Teacher Networks. The role of the Teacher Association and the intermediate district apparently needed study (SE-78-71-19-21).

They declare that 'There is a need for excellence in teaching, in learning, in administering, in providing support'. And they go on to make a 'plea for letting up on a sirgular emphasis on needs. The more needs are subdivided and specified, the more defensive many educators and institutions became, the less rational may be the response. We have to move to gain relief even before we know enough about our needs'. (SE-78-71-19-22).

I conclude that last time NSF tried to do the right thing. The social science curriculum I know best - MAN a course of study - and pre-

sumably others too, tried to give teachers new materials, help with new teaching methods, support on content information, assistance towards understanding the logic and process of a discovery/inquiry approach and towards the use of manipulative materials. NSF through this and other curricular enterprises seems to have been offering what the teachers were asking for. But it doesn't seem to have worked as had been hoped. Why?

Let us set out the situation starkly. Across the case studies the trend of evidence is that the quality of teaching is crucial for the quality of schooling, and that the quality of the teaching rests on the personal qualities and knowledge of the teacher as they have been developed into professional art by interaction with skills. That is not difficult to accept, I think. Further the Survey tells us that 'a sizeable number of teachers would like additional assistance in 'obtaining information about instructional materials, learning new teaching methods, implementing the discovery/inquiry approach, and using manipulative or hands-on-materials' (SE-78-71-Survey 16). The case studies, so far as the teaching methods needs are concerned, appear generally to confirm the teachers' diagnosis of their own situation. It all hangs together and looks like good common sense.

And yet this definition of needs is the outcome of a status survey which was commissioned following a rueful diagnosis of the results of a past policy of NSF funding, which in fact appeared to address rather directly that pattern of needs which is now reaffirmed. And further, the NSF and indeed the whole apparatus of in-service study in universities and colleges, not to mention school district supervision, might be expected to have impacted more evidently on the system in answer to such obvious and common sense needs. Surely, we could simply.... But it is not that simple.

WHAT WENT WRONG AND WHAT TO DO

What is amiss? The report under review gives some basis for answers, partly directly, partly because it is itself evidence of attitudes.

Let's start by getting it clear that development in the practice of the art of teaching is necessarily gradual and bought at great pains. One factor is the succession of generations of teachers. Sometimes advance comes because an innovative teacher or, better, a group of teachers - eludes the constraints of an institution that was shaped by old habits and of students to whom such habits are comfortable. Certainly the improvement of schooling is not a

shoulder-to-shoulder advance across a broad front. Nor is it a matter of management and organization. It depends upon the capture, colonization and settlement of new territories of understanding and practice. It is not about reform or pulling our socks up or adopting a ready-made solution: it is about the gradual dissemination of new cultures of classroom practice. It takes time and consistency of direction and protection from the distracting lure of patent remedies and fads.

In this advance the role of federal funding of curriculum materials would seem to be to support enterprises which need more development work than would normally be financed by a commercial publisher, or which take market risks greater than commercial publishers are taking or which answer a need of teaching which may be a growing point but has not yet come to bud in market terms. If this desideratum is accepted, the materials situation looks appropriate. In K-6 Social Studies five sets of materials have taken-up from 1-2 per cent of school districts. MACOS has 3%, Our Waking World 8% and Elementary Social Science Education Program Laboratory Units 12%. A couple of projects look to have drawn a blank. At grade 7-12 level, of 20 sets materials listed, one has 12%, one 10% and one 7% take-up, four have 3-4%, eight have 1-2% take-up and five are not in evidence (SE-78-72-Table B16-p.B24-B25). Taken together the use

by districts of federally funded curriculum materials in social studies is 25 percent for grades K-6 and 24 percent for grades 7-12 (SE-78-71-p.7). This strikes an outsider as appropriate take-up, and the success rate is undoubtedly better than that in commercial textbook publishing, where there are many failures for each success.

The urge towards higher take-up than this - for which there is some evidence - seems to indicate a misconception which lies at the heart of the gap between teacher needs and their fulfillment. It is that materials are there to push teachers towards change rather than to serve teachers who are engaged in self-development. There seems to be an assumption that university and system personnel and curriculum developers know how teaching should be moving forward but have problems in getting it across to the teachers. Not so. It is only by studying the leading edge of teachers that those outside the classroom can learn ways ahead. One of the reasons for the shortfall in meeting teachers needs - as Stake and Easley hint - is that people define those needs in offices instead of studying them in classrooms. A principal block to improvement seems to be that those who should be serviceable to the teacher are placed in a status position superior to the teacher. There needs to be more inverse accountability. Perhaps NSF could fund a developmental project in

teaching methods in which the developmental team were controlled by and accountable to teachers!

One brake on progress in the art of teaching seems to be ideas that seem logical in offices and burdensome in classrooms: the prime one emerging from this study is objectives analysis as a means of teacher development, a salutary discipline to get teachers minds clear. Stake and Easley quote an English consultant, Frances Stephens, who observed schools in the case study project:

> Students taught - and, in these two schools, for the most part very efficiently - within a conventional and conservative framework are following two curricula. The first is the body of established knowledge and procedures to which the learning encounter is intended to be instrumental. The second is the personality, which of course includes individual preferences and value-systems of the teacher, communicated in the learning encounter. Students of the teacher just mentioned must have learned, besides the facts and processes contained in the syllabus, his passionate concern for the careful discriminations and unremitting logic of historical method, as well as his commitment to an austere discipline that shuns delights and lives laborious days.

They comment on her observations:

> This seemed to be at the heart of the teachers' struggle, a struggle with which they get little or no help* It reflected and grew out of struggles with their own studies or at least that part of their studies in which they could take personal pride. It involved an intimacy, a sharing of pride and value commitment with their students, within the context of instruction in math, science, or social studies (CSSE-16-9).

And their asterisk leads us from their observation that...'they get little outside help' to the comment: 'Worse still, the few minutes they could devote to this struggle were increasingly conscripted for the formalization of instruction, such as objectives writing and testing'. This comment is amply borne out by the case studies, and there is evidence of other burdensome chores.

Lou Smith whose case study of Alte schools gives us the best picture of a high-morale school ('in a sophisticated well-to-do upper-middle-class suburban community' (CSSE-3-62) endorses the centrality of the teacher and, noting the prevalence in the district of the expression 'The "Strong" Teacher' he observes:

Within the district there's more than a fair amount of agreement on what this means. Almost universally, the following are included:

1) a deep and abiding knowledge and interest in the subject matter...

2) knowing what they want to do with the subject matter with kids at the age/grade level they are teaching;

3) being 'turned on', motivated, interested in their field;

4) conveying, stimulating, engaging the children in this set of learning, thinking, motivational processes; and

5) multi-dimensional aspects of personality and background - 'second suits' of strength (CSSE-3-76).

Later in his study, after interviewing a stronger teacher at length Smith has this pertinent comment to make:

In thinking about the situation stated by the teacher, it seems to me that one of the things that remains is the notion of the need to build in, both administratively and with one's peers, the kind of reward and

reinforcement and acclaim that comes with doing a good job. Somehow that didn't seem to come for him from anyone. That left him with a very strong, unhappy, disappointed feeling. As he said 'I went into a depression for six months.' Somehow, that seems to be a potent statement on the nature of things.

One of the problems of systems that are composed of 'stars', highly individualistic, competitive types of individuals, is that there isn't the sense of community that builds in the kinds of things that typically give those sorts of rewards and reinforcements. And that might well be a dysfunction of the type of system we've been talking about (CSSE-3-82).

The moral seems to be this. Locate the teachers who are expressing the need for self-development and don't then start talking to them. Listen first. You are listening to experts on the problems of achieving good teaching in schools. Then ask them for their ideas on what is needed in the way of support and research. And then see if you can live up to their suggestions. That is not how it has been. And it is not easy to achieve. Largely because so many in the superstructure and support structure of education don't listen. Like the First World War generals who did not seem to

hear the message from the trenches.

A focus for the improvement of presently inadequate support systems seems to be in providing contexts for colleagual conference and, too, rewards for this kind of activity. Standards are norms created not by tests but by groups. Examinations and tests may monitor whether standards are good, but they do little or nothing to create good standards.

Smith proposes a 'Center for the Analysis of Teaching', and sets out ideas towards it (CSSE-3-95 et seq). It has to be a center in which classroom teachers carry high status, I think. And certainly, as he believes, it must be concerned with the development, not the direction of teaching.

THE ISSUE OF CONTROVERSIALITY: A CONTROVERSIAL ISSUE

In social studies many developments of quality will have to face the half-hidden problem we have not yet examined: that of the controversiality of content. The review of the literature throws it up clearly as an issue:

> One of the few things on which social studies educators seem to have been able to agree is that academic freedom and the difficulties of dealing with controversial is-

> sues in the classroom pose a problem of particularly strong significance for social studies teachers, due to the inherently 'hot' nature of the subject matter. (SE-78-73-Vol. III-p.11).

But oddly the survey didn't tap into this as a problem. And for the most part neither do the case studies.

> A biology teacher observes:
>
> Evolution has never come up as an issue. I don't know. My personal view is probably close to safe because I don't see any divergence between the theory of evolution and a religious viewpoint. I suppose I'm not really radical. Maybe that's the reason I haven't had any feedback. If I were an atheist, I suppose that might present a problem. And the students don't make it a problematic discussion either. Never had anyone do that. Here again, our students are pretty much of one mind. They're pretty closed in the ideas they have. I've hardly had any feedback from the community (CSSE-4-11).

And Terry Denny can write:

> The only junior high school social studies teacher in the district that I saw ap-

proaching what could be called a controversial topic had this to say after class:

> 'The teaching of man's relation to himself and others necessarily brings up religious, political, sexual, ethnic, racial problems and deals with very touchy subjects because of, what shall we say, the Bible Belt? ....If you mention certain things to certain students, it goes home and the school board gets calls about it....this is not what the community wants so we don't do it. (CSSE-1-53).

Only a murmur comes through.

Possibly my thought that social studies of high quality must be speculative and intellectually adventurous, and that such a line of development is not possible without facing squarely the problem of teaching controversial issues is prejudice prompted by my own interest. But certainly I remain puzzled by the failure of the issue to emerge in the report. For the current story is that the trail to this self-examination of science and social science curricula started from a by-no-means-gentle attack on MAN: A Course of Study.

That's a curriculum we have to defend to English teachers because they start by fearing it will disseminate the American way of life.

Its high-achieving salmon, its fiercely familial herring gulls, its baboons locked into a dominance hierarchy like good corporation men and its frontiersmen Eskimo seem to us to be lineal descendents of 'A mule is an animal with long funny ears...' It's a good social studies curriculum, well adapted to discovery and inquiry teaching. Better than anything we've got at its level. But inquiry teaching means you have got to attack it. When you do, you find that at the core there is still the positivist implication that perhaps science is true. Real true. Like some people feel the Bible is. Not just theory - like evolution. I'm examining a teacher's dissertation for a master's degree right now and I read: 'In fact, the importance of supporting evidence is given greater weight in history than in many of the natural sciences, because it is insisted that the historian's account must be true not only as a whole, but also in its component parts. It could be argued that an historian would never have been allowed to present the theory of evolution!' (Stanley 1980)

Perhaps there are elements in MAN: A Course of Study which urgently need to be taught by those inquiry and discussion methods with which teachers say they need help, and which surface so little in the classrooms observed in the case studies. Perhaps, too, you cannot always avoid controversy by keeping in accord with - or at least in touch with - what the community

thinks, when some people in that community believe in science the way some people believe in God!

CONCLUSION

That is an appropriate thought to lead to a final assessment of the credibility of this major research effort. To this reviewer the NSF seems to have got its money's worth. The aim of the research was ambitious. Its scale was large and its timing short and sharp. The performance, as one would expect, is uneven. For example, some of the case studies are really very thin. But this is a first effort in multi-site case study and it is the best of the studies that will set standards for the future. Then too, the main survey is in many respects weaker than the survey which grew out of the field study, strongly suggesting that survey design needs case study as a guide. The summary of the survey, oddly enough, seems to be less satisfactory than that of the field study. The literature review is thorough, but could profitably have challenged an interpretation in the genre of intellectual history. Only the field study has an index, though that is certainly a careful one.

If we have to have a man-of-the-match award, then the field study takes it. True, this is partly because it is breaking new

ground, but it is not an award simply for pioneering. Some of its quality undoubtedly derives from the unusual experience of its fieldworkers and the profoundly thoughtful cross-case synthesis by Stake and Easley. But it also has the important quality intrinsic to its conception and form that it challenges our judgement more than survey or review. We all like to be credited with judgement. And it seems important to cultivate it in fields of action such as education where one cannot leap from results to solutions.

The picture which emerges should be useful to the National Science Foundation. The skills and sensitivities of individual teachers are paramount. To develop those, teachers need access to materials and ideas, to professional education which focusses on the development of teaching as an art, and to support systems capable of making the strain of bootstrapping not merely tolerable, but rewarding. So far as NSF is concerned, its Institutes and other in-service activities are generally praised, and a reasonable proportion of advisory and supervisory personnel believe its curriculum efforts improved classrooms.

As I read the situation, in-service development needs curriculum development and research in teaching. The error has been to see in-service education as the servant of curricu-

lum reform rather than curriculum as a research field to serve in-service education. A lot of capital has accumulated in curriculum materials. What is now needed is the thrust to use those materials in the service of teacher development in the rather free way that jazz musicians use the standards on which they improvise to improve their art. The marching band was the wrong model for educational advance, it didn't leave enough space for the solos.

REFERENCES

Barzun, Jacques (1959) The House of Intellect. London: Secker & Warburg.

Cobbett, William (1830) Rural Rides in the Counties of Surrey, Kent, Sussex...with economical and political observations relative to matters applicable to, and illustrated by, the state of those counties respectively. London: William Cobbett. Cobbett's 'Rural Rides' began to appear in the Political Register in 1821. The 1830 collection was the only one published during Cobbett's lifetime. The best modern edition is probably: Rural Rides in the Southern, Western and Eastern Counties of England, together with Tours in Scotland and in the Northern and Midland Counties of England, and Letters from Ireland by William Corbett, edited by G.D.A. and Margaret Cole. London: Peter Davies, 1930.

MacDonald, Barry (1973) 'Innovation and Incompetence' 89-92 in Towards Judgement, the publications of the Evaluation Unit of the Humanities Curriculum Project 1970-72 edited by Don Hamingson. Norwich, England: C.A.R.E. Occasional Publications No. 1

MACOS (1970) Man: A course of Study Evaluation, Statement of aims on p. 5. Washington, D.C.: Curriculum Development Associates.

Stanley, Nicholas (1980) A Critical View of Assessment of History Coursework at 16+ Unpublished M.Ed. dissertation University of Liverpool.

THE UNSCIENTIFIC AMERICAN -- SOME RANDOM THOUGHTS

A comment
by
Jerrold R. Zacharias*

---

*Jerrold R. Zacharias is Institute Professor Emeritus of the Massachusetts Institute of Technology, having retired from teaching in the Department of Physics there in 1970. He was the organizer of the Physical Science Study Committee which pioneered in the development of new physics curricula for high schools, in the 1950's and 1960's. At the present time he continues his work on school curriculum projects at the Education Development Center in Newton, Massachusetts.

Asked to make a few comments relevant to two reviews of three extensive surveys of twenty years of effort to improve the learning of science in the schools of the United States, I must establish some frames of reference.

As this is written, the President of the United States has asked for an opinion on the following question from top officials of the

National Science Foundation and the Department of Education:

"Are the government's policies for science and engineering education adequate for the country's long-term strength?"

They are not adequate, and there are no government programs for making them adequate.

The answer to the President's question about technical education would be the same for any other school subject. The United States Government is doing nothing worth mentioning to improve the quality of public school education. Instead, it merely sends a dole of federal tax money back to the localities where it is inflexibly tied to projects mandated by Congress which do not bring widespread improvements in education.

The quality of learning in most American public schools is both poor and going downward, rather than good and going up. The chief reason why Washington is doing nothing about this situation is political. In the years since the present school crisis began to pile up, the successive presidents of the United States have not committed themselves to a personal, determined, active and sustained interest in American education -- of the sort necessary to break through the political inertia, get needed legis-

lation on the books, and command the responsible government officials to adopt a new mission and stay with it.

There is a serious question whether the best program for science education, by itself, could not accomplish its purpose. When installed it would be an island of sanity in the midst of an education system in acute and comprehensive disorder. It will depend for its success on a large number of ancillary factors, seemingly not the business and concern of science educators. They include negative trends in society, politics, management, finance, the choice and ability of teachers as well as their training, and a host of distracting influences on the mind and character of today's young.

Since the learning of good science is a high and valuable priority today, it becomes specially important not only to develop the best curriculum but to examine its surround and to design it realistically. At the outset it will have to be carefully adjusted to disorder and instability, and then go to work on improving its life support system. If this were well done, science education could lead the way out of the compound disarray of today's schools.

Figure 1 of the paper by Rita Peterson shows the annual funding by the NSF of the basic elements required for improving science educa-

tion in the U.S. Some aspects merit comment.

1. The total funds for the twenty years from 1955 to 1975 is reported as 650 million dollars. That sum may sound large unless it be compared with a rough estimate of the total spent by American schools during the same period. An estimate which is cavalier about inflation and dollars shows that the schools spent roughly 50 billion dollars per year and for the twenty years this becomes a trillion dollars, -- a thousand billion, a million million. Is science education so trivial that it merits such a small percentage for making it worth doing?

2. The funds for helping teachers cope with new ideas (or even old ones) in ways which were mandated by the integrated classroom decisions of the Supreme Court may sound large at 5 million dollars per year for a million teachers, or five dollars per teacher per year. This sum is low by a factor of a hundred.

Since the reviews and the reports on which they are based are essentially arrived at by looking backward, not forward, this is not the place to outline in detail any mechanisms for helping teachers cope with the varieties of students and topics that are appropriate for any learning, especially the sciences, the applied sciences, and the technologies. But it is true that proposals are being made to the NSF and to

the Department of Education which could easily be funded and, if so, could be successful. A succinct description of a sure-fire procedure can be found in a report of a Panel of the National Research Council on the State of School Science, dated June 1979 (page 45). The plan is called "Science and Mathematics Teacher Resource Centers".

3. No graph similar to Figure 1 is shown for the Office of Education's budgets for science education -- or any facet of it. The reasons for this omission are obvious and shameful. The Office of Education did not recognize science as worthy and completely necessary.

Section 4, "Conclusions and Commentary," of the paper by Rita Peterson is most agreeable to me. She puts her finger on the nub of the matter when she says, "Excellence in science education was attained when it was important enough; mediocrity returned when concern was withdrawn." This statement puts the bee onto the backs of the scientists, the applied scientists, and the technologists not to mouth complaints but to get into positions of power on school boards and school committees. Education should be led by educated people not by those who lead it now.

The paper by Lawrence Stenhouse admittedly focuses on the Social Sciences, which require more sophistication and political insight than do the phenomena related to non-human nature. In my view, Man, A Course of Study, to which he frequently refers, should never have got itself into the creation/evolution controversy. But having carelessly done so, it opened the dikes to our critics in an unfortunate way. Stenhouse should have analyzed this problem and should have understood better the procedures actually used in the development of curriculum materials. The leaders of these reforms did not use the marching band as a model; they worked with teachers, pupils, scholars, salesmen, publishers, administrators, parents qua parents and so on. So when I criticize as I do, the "New Math" and bits of MACOS, I wonder how many mistakes I have made.